INDEX

For Doorkeeper's use

Geof. Couper

A

HANDBOOK

TO THE

MUSEUM

OF

PRACTICAL GEOLOGY,

JERMYN STREET, LONDON, S.W.

LONDON:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE,
BY EYRE AND SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.

SOLD ONLY AT THE MUSEUM.

1896.

Price Sixpence.

LIST OF MAPS, SECTIONS, AND OTHER PUBLICATIONS OF THE GEOLOGICAL SURVEY OF ENGLAND AND WALES.

THE Maps are those of the Ordnance Survey, geologically coloured by the Geological Survey of the United Kingdom, under the Superintendence of Sir ARCH. GEIKIE, D.Sc., LL.D., F.R.S., Director General.

(For Maps, details of Sections, and Memoirs issued by the Geological Survey, *see* "Catalogue.")

ENGLAND AND WALES.—(Scale one-inch to a mile.)

Maps marked * are also published as Drift Maps. Those marked † are published only as Drift Maps.

Sheets 3*, 5, 6*, 7*, 8*, 9, 11 to 22, 25, 26, 30, 31, 33 to 37, 40, 41, 44, 47*, 64*, 65†, 69†, 70*, 83*, 86*, price 8*s.* 6*d.* each.

Sheet 4, 5*s.* Sheets 2*, 23, 24, 27 to 29, 32, 38, 39, 58, 84†, 85†, 4*s.* each.

Sheets divided into quarters; all at 3*s.* each quarter-sheet, excepting those in brackets, which are 1*s.* 6*d.* each.

1*, 42, 43, 45, 46, NW, SW, NE*; SE, 48, NW†, SW*, NE†, (SE*), (49†), 50†, 51*, 52 to 57, (57 NW), 59 to 63, 66 SW† NE†, NW*, SE†, 67 N†, (S†), 68 E†, (NW*), SW†, 71 to 75, 76. (N) S, (77 N), 78, 79, NW*, SW, NE*, SE*, 80 NW*, SW*, NE*, SE*, 81 NW*, SW, NE, SE, 82, 83*, 87, 88, NW, SW*, NE, SE, 89 NW* SW*, NE, SE* 90 (NE*), (SE*), 91, (NW*), (SW*), NE*, SE*, 92 NW*, SW*, NE, SE, 93 NW, SW, NE*, SE*, 94 NW†, SW†, (NE†), SE†, 95 NW*, NE*, (SE*), 96 NW*, SW*, NE*, SE*, 97 NW*, SW*, NE*, SE, 98 NW, SW, NE*, SE, 99 (NE*), (SE*), 101 SE, NE*, NW*, SW*, 102 NW*, NE*, SW*, SE*, 103*, 104*, 105 NW*, SW*. (NE*), SE*, 106 NW*, SW*, NE*, SE*, 107 SW†, NE*, SE*, 108 SW*, NE*, SE*, 109 NW*, SW,* SE*, 110(NW*), (NE*), SE*, SW*.

New Series.—I. of Wight†, 6*s.* I. of Wight with Mainland* (330, 331, 344, 445), 8*s.* 6*d.* 330*, (331*), (332*), 333*, 334*.

INDEX MAPS :—(Scale 4 miles to 1 inch.)

WALES, &c.—Sheets 9 (1-inch Maps, 37, 38, 40, 41) ; 10 (35, 36, 42, 43) ; 14 (57–59) ; 15 (55, 56, 60, 61) ; 19 (75–78) ; 20 (73, 74, 79, 80), 3*s.* 6*d.* each.

ENGLAND AND WALES.—Sheets 6 (E. Yorkshire), 7*s.* 6*d.*; 12 (London and lower part of Thames Basin), 10*s.* 6*d.*; 14 (Torquay to I. of Wight) 9*s.*; 15 (Chichester to Hastings), 4*s.* 6*d.*

HORIZONTAL SECTIONS,

1 to 147, England, price 5*s.* each.

VERTICAL SECTIONS,

1 to 79, England, price 3*s.* 6*d.* each.

COMPLETED COUNTIES OF ENGLAND AND WALES, on a Scale of one-inch to a Mile.

Sheets marked * have Descriptive Memoirs. Sheets or Counties marked † are illustrated by General Memoirs.

ANGLESEY†,—77 N, 78.
BEDFORDSHIRE,—46 NW, NE, SW†, SE†, 52 NW, NE, SW, SE.
BERKSHIRE,—7*, 8†, 12*, 13*, 34*, 45 SW*.
BRECKNOCKSHIRE†,—36, 41, 42, 56 NW, SW, 57 NE, SE.
BUCKINGHAMSHIRE,—7* 13* 45* NE, SE, 46 NW, SW†, 52 SW.
CAERMARTHENSHIRE†, 37, 38, 40, 41, 42 NW, SW, 56 SW, 57 SW, SE.
CAERNARVONSHIRE†,—74 NW, 75, 76, 77 N, 78, 79 NW, SW.
CAMBRIDGESHIRE†,—46 NE, 47*, 51*, 52 SE, 64*.
CARDIGANSHIRE†,—40, 41, 56 NW, 57, 58, 59 SE, 60 SW.
CHESHIRE,—73 NE, NW, 79 NE, SE, 80, 81 NW*, SW*, 88 SW.
CORNWALL†,—24†, 25†, 26†, 29†, 30†, 31†, 32†, & 33†.
CUMBERLAND,—98 NW, SW*, 99, 101, 102 NE, NW, SW, 106 SE, SW, NW 107.
DENBIGH†,—73 NW, 74, 75 NE, 78 NE, SE, 79 NW, SW, SE, 80 SW.
DERBYSHIRE†,—62 NE, 63 NW, 71 NW, SW, SE, 72 NE, SE, 81, 82, 88 SW, SE.
DEVONSHIRE†,—20†, 21†, 22†, 23†, 24†, 25†, 26†, & 27†.
DORSETSHIRE,—15, 16, 17, 18, 21, 22. Hor. Sect. 19, 20, 21, 22, 56.
DURHAM,—102 NE, SE, 103, 105 NE, SE, SW, 106 SE.
ESSEX,—1*, 2*, 47*, 48*.
FLINTSHIRE†,—74 NE, 79.
GLAMORGANSHIRE†,—20, 36, 37, 41, & 42 SE, SW.
GLOUCESTERSHIRE,—19, 34*, 35, 43 NE, SW, SE, 44*.
HAMPSHIRE,—8†, 9†, 10*, 11†, 12*, 14, 15, 16.
HEREFORDSHIRE,—42 NE, SE, 43, 55, 56 NE, SE.
HERTFORDSHIRE,—1† NW, 7*, 46, 47*.
HUNTINGDON,—51 NW, 52 NW, NE, SW 64*, 65.
KENT†,—1† SW & SE, 2†, 3†, 4*, 6†.
LANCASHIRE,—79 NE, 80 NW*, NE, 81 NW, 88 NW, SW†, 89, 90, 91, 92 SW, 98.
LEICESTERSHIRE,—53 NE, 62 NE, 63*, 64*, 70*, 71 SE, SW.
LINCOLNSHIRE†,—64*, 65*, 69, 70*, 83*, 84*, 85*, 86*.
MERIONETHSHIRE†,—59 NE, SE, 60 NW, 74, 75 NE, SE.
MIDDLESEX†,—1† NW, SW, 7*, 8†.
MONMOUTHSHIRE,—35, 36, 42 SE, NE, 43 SW.
MONTGOMERYSHIRE†,—56 NW, 59 NE, SE, 60, 74 SW, SE.
NORFOLK†,—50 NW*, NE*, 64*, 65*, 66*, 67, 68*, 69.
NORTHAMPTONSHIRE,—64*, 45 NW, NE, 46 NW, 52 NW, NE, SW, 53 NE, SW, & SE, 63 SE, 64.
NOTTINGHAM,—70*, 71* NE, SE, NW, 82 NE*, SE*, SW, 83, 86, 87* SW.
OXFORDSHIRE,—7*, 13*, 34*, 44*, 45*, 53 SE*, S.W.
PEMBROKESHIRE†,—38, 39, 40, 41, 58.
RADNORSHIRE,—42 NW, NE, 56, 60 SW, SE.
RUTLANDSHIRE†,—this county is wholly included within Sheet 64.*
SHROPSHIRE,—55 NW, NE, 56 NE, 60 NE, SE, 61, 62 NW, 73, 74 NE, SE.
SOMERSETSHIRE,—18, 19, 20, 21, 27, 35.
STAFFORDSHIRE,—54 NW, 55 NE, 61 NE, SE, 2, 63 NW, 71 SW, 72, 73 NE, SE, 81 SE, SW.
SUFFOLK,—47,* 48,* 49*, 50*, 51*, 66* SE*, 67*.
SURREY,—1 SW†, 6†, 7*, 8†, 12†.
SUSSEX,—4*, 5†, 6†, 8†, 9†, 11†.
WARWICKSHIRE,—44*, 45 NW, 53*, 54, 62 NE, SW, SE, 63 NW, SW, SE.
WESTMORLAND, — 97 NW*, SW*, 98 NW, NE*, SE*, 101 SE*, 102.
WILTSHIRE,—12*, 13*, 14, 15, 18, 19, 34*, and 35.
WORCESTERSHIRE,—43 NE, 44*, 54, 55, 62 SW, SE, 61 SE.
YORKSHIRE,—85–88, 91 NE, SE, 92–97*, 98 NE*, SE*, 102 NE, SE, 103 SW. SE, 104*.

A

HANDBOOK

TO THE

MUSEUM OF PRACTICAL GEOLOGY,

JERMYN STREET, LONDON, S.W.

LONDON:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE,
BY EYRE AND SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.

SOLD ONLY AT THE MUSEUM.

1896.
Price Sixpence.

PREFACE.

SOON after the Museum of Economic Geology was founded in Craig's Court, Charing Cross, a small guide-book was written by the late Mr. Thomas Sopwith, of Newcastle-on-Tyne, and published in 1843 by Mr. John Murray. On the transference of the Museum, in 1851, to the present building in Jermyn Street, a "Descriptive Guide" was officially prepared by the late Mr. Robert Hunt, the keeper of Mining Records, and was published in 1857. A second edition was issued in 1859. Eight years afterwards an amplified edition was prepared by Mr. Rudler, at that time assistant-curator; and in 1877 a fourth edition was published.

The work has now been out of print for several years; but, in view of changes which were pending in the arrangement of the Museum, the preparation of a new edition has been delayed.

In now publishing the guide-book afresh it has seemed desirable, for several reasons, to modify its original form. So much additional matter had been introduced into the successive editions, that the book had grown too large; and in order to keep the price within moderate limits a type was used, which many visitors found inconveniently small. In certain parts, moreover, the work had perhaps acquired rather too much the form of an inventory.

The curator, Mr. F. W. Rudler, has therefore prepared a new guide, under the title of a "Handbook," in which, while the essential parts of the earlier work have been retained, great changes have necessarily been made in order to bring it into harmony with the present condition of the Museum. The book has been, in large part, re-written, and now contains, it is hoped, all the information which the general visitor is likely to need, given in such detail as is consistent with its moderate size.

E 87039. 5000.—1/96. Wt. 2629.

For different sections of the Museum more detailed Catalogues and Guides have been published, or are now in course of preparation. The following have already been published :—

- Handbook to the Collection of British Pottery and Porcelain, 1893.
- Catalogue of the Tertiary and Post-Tertiary Fossils, 1878.
- Catalogue of the Cretaceous Fossils 1878.
- Catalogue of the Cambrian and Silurian Fossils, 1878.
- Catalogue of the Mineral Collection, 1864 (out of print).
- Catalogue of the Models, 1865 (out of print).
- Catalogue of the Fossils, 1865 (out of print).
- Catalogue of the Rock Specimens, 3rd ed., 1862 (out of print).
- Catalogue of British Pottery and Porcelain, 3rd ed., 1876 (out of print).

The following are now being prepared: —

- Handbook to the Rock Collection.
- Handbook to the Palæontological Collections.

ARCH. GEIKIE,
Director.

Museum of Practical Geology,
Jermyn Street, S.W.,
30 November, 1895.

PLANS OF THE MUSEUM.

In order to assist the visitor, several plans of the various parts of the Museum, showing the position of the principal groups of objects, are placed in conspicuous positions.

CONTENTS.

HANDBOOK TO THE MUSEUM.

Introduction.

The Museum of Practical Geology owes its origin to a representation submitted to the Chancellor of the Exchequer, in 1835, by Sir Henry Thomas De la Beche, the founder of the Geological Survey of the United Kingdom. During the progress of the Survey, which had been commenced a few years previously in the south-west of England, the officers had obtained specimens of minerals, rocks, and fossils, which it was clearly desirable to preserve. It was suggested by De la Beche that these specimens would form an excellent nucleus of a museum of a special character, designed partly to illustrate the work of the Survey and partly to show the application of geology to the useful purposes of life, and especially to exhibit the mineral resources of the British Isles. In 1837, Lord Duncannon, then Chief Commissioner of Woods and Forests, allotted apartments for this purpose at No. 6, Craig's Court, Charing Cross; and thus was founded what was then termed "The Museum of Economic Geology."

An institution so practical in character and so peculiarly adapted to the wants of a great commercial and manufacturing community at once attracted the sympathy of those engaged in our mining and metallurgical industries. Contributions of appropriate specimens were thus readily secured, and so rapid was the growth of the collections that, in the course of a very few years, it became necessary to secure ampler accommodation. Eventually the Government authorised the erection, by the late Mr. James Pennethorne, of the present building, which is situated between Piccadilly and Jermyn Street, and is officially designated "The Museum of Practical Geology."

On May 12, 1851, the Museum was formally opened by the Prince Consort in the presence of a distinguished assembly. His Royal Highness, in acknowledging an address presented by the Director, spoke as follows :—

"In thanking you for the address which you have just read to me, I would also express the sincere gratification with which I witness the opening,—in a form more likely to make it generally and practically useful,—of an institution the progress of which I have long watched with much interest, and the want of which has been long felt in this country. I rejoice in the proof thus afforded of the general and still increasing interest taken in scientific pursuits; while science herself, by the subdivision into the various and distinct fields of her study, aims daily more and

more at the attainment of useful and practical results. In this view it is impossible to estimate too highly the advantages to be derived from an institution like this, intended to direct the researches of science and to apply their results to the development of the immense mineral riches granted by the bounty of Providence to our isles and their numerous colonial dependencies. It will always give me the greatest pleasure to hear of, and, as far as I am able, to contribute to, the continued success of the Museum of Practical Geology."

The Museum building consists of the following parts, open to the public, viz.:—

1. The *Vestibule* and *Hall.*

2. The *Principal Floor,* reached by two staircases, one on each side of the Hall, near the Vestibule. At the end of this floor, next to the entrance, is the section devoted to the *Ceramic Collection,* whilst at the further end of the floor are the *Model Rooms.*

3. The *Lower Gallery,* devoted mainly to British Palæozoic fossils and reached by a staircase on each side of the Principal Floor. At the northern, or curved, end of this gallery is the entrance to the galleries of the two Model Rooms.

4. The *Upper Gallery,* containing the collection of British Secondary and Tertiary Fossils, and reached by a staircase on each side of the Lower Gallery.

5. The *Rock Room,* containing the Petrographical Collections, situated at the south end of the Upper Gallery.

Besides the public rooms and galleries mentioned above, the building contains the offices of the Museum and of the Geological Survey, the Library, a Lecture-room, and a small Laboratory.

THE HALL.

On entering the Museum from Jermyn Street the visitor passes into the Vestibule, the walls of which are decorated with polished slabs of Derbyshire alabaster, on a base of grey Irish granite. The steps leading from the Vestibule to the Hall are of Portland stone, while the pilasters (Nos. 7 and 197) at the head of the steps are of the grey granite of Peterhead, Aberdeenshire. In front of the visitor are bronzed zinc busts of HER MAJESTY THE QUEEN (No. 1) and the late PRINCE CONSORT (No. 3) mounted on columns of red Peterhead granite (Nos. 2 and 4).

The centre of the Hall is occupied by a handsome tesselated pavement, executed in Messrs. Minton's tesseræ from designs taken from various pavements discovered towards the close of the last century among the remains of a Roman villa at Woodchester in Gloucestershire. The central area is surrounded by polished slabs of grey Aberdeen granite, and these again by others of red Peterhead granite, the whole being bordered by a

guilloche in Minton's encaustic tiles. Similar tiles form a pavement at the top of the steps leading from the Vestibule, and also on the north of the tesselated pavement, around the statue of Hercules. The general pavement in the Hall is of Portland stone, a material which also forms the columns supporting the floor above.

The most prominent object in the Hall, immediately fronting the visitor on his entry, is a copy of the Farnese Hercules (No. 116), carved in Portland stone by the late Mr. C. H. Smith.

For a description of this limestone, *see* p. 31.

Busts of Geologists.

Around the central tesselated pavement and in various other parts of the hall are appropriately placed busts of a few distinguished men who have advanced the science of geology. To increase their interest to the visitor the following brief biographical notices are introduced:

Sir Henry Thomas De la Beche, C.B.—*Copy by E. C. Papworth, from a bust by E. H. Baily, R.A. No.* 198.

This eminent geologist, the founder of this institution, was born in 1796. Having lost his father at an early age, he resided for some years with his mother in Devonshire, then at Charmouth in Dorsetshire, and afterwards at Lyme Regis. To his early associations may be referred those studies which became the business of his life; and it is interesting to note the love with which he always returned to the consideration of the rocks of Western England, amongst which in his boyhood he had rambled; always finding, never seeking, pleasure. In 1810 Henry de la Beche entered the Military School at Great Marlow; but he never embraced the profession of arms, and in 1817, entering the Geological Society, he enrolled himself in that select band, who were then struggling to establish geology as a science, and of which he soon became a guiding spirit, and eventually the leader. Mr. De la Beche always exhibited great activity of mind, and numerous memoirs and other publications were continually proceeding from his pen. Among his larger works, issued as independent publications, may be mentioned his *Geological Observer* and his *Researches in Theoretical Geology.*

In 1835 was commenced the great work of the Geological Survey of the United Kingdom, which may be regarded as one of the first scientific inquiries fairly recognised by the Government of this country. Mr. De la Beche was attached to the Ordnance Survey, with power to carry out a geological survey of the western counties, and to publish his results on the one-inch Ordnance maps, by geological colouring. Upon this important point the words of his successor, Sir Roderick I. Murchison, spoken on receiving from the Geological Society the

Wollaston medal for his friend, then in his last illness, are especially to the purpose :

"At his own expense he traced the boundaries and relations of certain rock formations, and laying them down on the Ordnance Survey maps, accompanied by illustrative sections, he thus took the first step in leading public men (otherwise little versed in our science) to see the good which must result from the extensive application of such a scheme, in making all proprietors alive to the importance of obtaining a better acquaintance with the subsoil of their estates.

"Having gradually attracted the notice of the Government, and having obtained the use of rooms in Craig's Court, and the employment of a limited sum of the public money, Sir H. de la Beche then attached to his new-formed establishment able men of science, who could decipher formations in the field, describe the fossils they contained, or chemically analyse the structure of the rocks and their associated minerals. Soon filling to repletion the small space allotted to him with models of mines, illustrative drawings, and specimens of fossils, ores, and building stones, he convinced our rulers, and particularly the illustrious statesman Sir Robert Peel, that the dignity and interests of the country required an adequate and appropriate building should be erected and exclusively devoted to the fulfilment of a project so lucidly devised, and thus far so well realised. *Then arose, very much after the design of the accomplished director himself, that well adapted edifice in Jermyn Street, which to the imperishable credit of its author, stands forth as the first palace ever raised from the ground in Great Britain by the Government, which is entirely devoted to the advancement of science.*"

For his zealous labours in the cause of geological science, the Director-General of the Geological Survey was knighted by his Sovereign. On the continent, too, the labours of Sir Henry De la Beche were fully appreciated; he was created a knight commander of the Danish order of Danebrog, and of the Belgian order of Leopold; he was elected a corresponding member of the Institute of France, and member of various foreign academies. On the 13th of April 1855 Sir Henry Thomas De la Beche died, having retained his mental energies unimpaired to the last.

The bust is mounted on a pedestal of green ophicalcite, or serpentinous marble, from Connemara (No. 182) (*see* p. 29).

Sir Roderick I. Murchison, Bart., K.C.B.—*An original bust by H. Weekes, R.A.*, 1871. *Bequeathed by Sir R. I. Murchison. No.* 195.

Sir Roderick Impey Murchison, who succeeded Sir Henry De la Beche as director of this institution, was born at Tarradale, in Ross-shire, on February 19, 1792. Intended for the army, he was educated at the Royal Military College at Great Marlow, and in 1807 he obtained a commission in the 36th Foot. During his military life he saw active service in the Peninsula, and was present at the battle of Vimieria and the retreat on Corunna. On the conclusion of the war he married the daughter of General Hugonin, and soon afterwards quitted the army, though it was not until 10 years later that his attention was turned, by Sir Humphry Davy's influence, to scientific pursuits. His first practical lessons in geology were received from Dr. Buckland, whose enthusiasm incited Murchison to enter the field as an

original observer, and thus determined his future career. In 1825 he contributed his first paper to the Geological Society, of which he was henceforth one of the most prominent members. Murchison's great work, the work with which his name will always be identified, was that of determining the succession of a large series of the older rocks, which had previously received but little attention from geological observers. This task he commenced in 1831 by working on the rocks of Wales in conjunction with Professor Sedgwick, the two proceeding, however, from different base-lines. Sedgwick's labours lay among the older disturbed rocks of North Wales, where he established his "Cambrian System;" Murchison's among the newer rocks of South Wales and the border counties, where he laid the foundation of his "Silurian System." The famous work bearing as its title *The Silurian System* was published in 1839. Soon afterwards Murchison's attention was turned to the geology of Russia, and in 1840 he visited a part of the empire in company with the French geologist, M. de Verneuil. The following year he returned and made a more extended survey, aided by Count Keyserling, and encouraged by the Emperor Nicholas, but it was not until 1845 that he published his fine work, the *Geology of Russia and the Ural Mountains.* Some years later he brought out, under the title of *Siluria*, a large volume giving a general description of the older rocks, or a summary of palæozoic geology.

At an early period of Murchison's geological career he had shown, in conjunction with Sedgwick, that the slaty rocks of Devonshire are approximately of the same geological age as the red sandstones of Herefordshire, and thus established the "Devonian System." The formation of the "Permian System" was suggested at a later date by his travels through the old kingdom of Perm, in Russia, where he found a large development of rocks of this geological age. In 1846 Mr. Murchison received the honour of knighthood, and on Sir H. De la Beche's death, in 1855, he was appointed Director of this Museum and of the Geological Survey of the United Kingdom. He was one of the original founders of the British Association, and presided over its meeting at Southampton in 1846. Geographical science shared his attention with geology, and from 1844 to the time of his death he was almost perpetual President of the Royal Geographical Society. Through his influence a chair of Geology and Mineralogy was established in the University of Edinburgh in 1871, and towards the endowment of this chair he contributed 6,000*l.* The "Murchison Professorship," as he wished it to be called, was held for many years by his biographer, Sir Archibald Geikie, the present Director-General of the Geological Survey. Sir Roderick died on October 22, 1871.

Murchison's marble bust is mounted on a column of red granite from Mull (No. 196) and is placed on the western side of the steps, leading from the vestibule to the Hall.

Sir Andrew Crombie Ramsay, LL.D., F.R.S.—*An original model, by the donor, Mr. William Davis. No.* 181.

On Murchison's death in 1871, Professor A. C. Ramsay, who had been an officer of the Geological Survey for upwards of 30 years, received the appointment of Director-General of the Survey, and Director of the Museum of Practical Geology. Ramsay was born in Glasgow, on January 30, 1814. Although not strictly trained for a scientific career, he acquired, as a young man, a strong taste for geological pursuits, mainly through the influence of his friend Professor Nichol. In view of the meeting of the British Association in Glasgow, in 1840, Ramsay became actively engaged in the work of local organisation; and at the meeting, he exhibited and described a geological model of the Isle of Arran, which he had constructed from his own survey. This model—now exhibited in the museum—attracted much attention at the time; and through the influence of Murchison, the young geologist was soon afterwards introduced to De la Beche, from whom he received, in the spring of 1841, an appointment on the staff of the Geological Survey.

In 1848, Mr. Ramsay became Professor of Geology in University College, London; but, after a very short tenure, he relinquished this position in order to accept the lectureship on geology at the Royal School of Mines. Much of Professor Ramsay's official life was spent amongst the old rocks of Wales, unravelling the complexities of its geological structure, and explaining the origin of its diversified scenery. One of his earliest survey memoirs was "On the Denudation of South Wales," and one of his latest works, a new edition of his "Geology of North Wales." Glacial geology had much fascination for Ramsay, and in 1860, he published a popular little volume entitled *The Old Glaciers of Switzerland and North Wales.* Sir Andrew Ramsay, who received the honour of knighthood on his official retirement in 1881, died at Beaumaris, in Anglesey, on December 9, 1891. His life has recently been written by his successor, Sir Archibald Geikie.

The bust of Sir A. C. Ramsay is mounted on a column of pink granite from Corrennie, in Aberdeenshire (No. 182).

James Hutton, M.D.—*An original bust by Patric Park. No.* 119.

James Hutton was born at Edinburgh, on June 3rd, 1726, and in 1740 he entered the university of his native city, as a student of medicine. Dr. Hutton devoted much attention to chemistry and to agriculture; and when seeking information on rural economy, he appears first to have acquired a taste for mineralogy, and, as he himself expresses it, "became remarkably fond of studying the surface of the earth."

In 1777 Dr. Hutton gave to the world his first publication, "Considerations on the Nature, Quality, and Distinctions of

Coal and Culm." During 30 years, Dr. Hutton's attention was centred in the discussion of great geological problems, and at length he communicated to the Royal Society of Edinburgh his famous "Theory of the Earth," a most remarkable and original work, which was in truth the foundation of modern geology. In 1795 this was re-published in an amplified form in two volumes. Dr. Hutton died in 1797, and of him, his biographer, Prof. Playfair, has said:—"The acquisitions of fortune never excited more lively expressions of joy in other men than hearing of a new invention, or being made acquainted with a new truth, would at any time do in Dr. Hutton." "He would rejoice over Watts' improvements on the steam engine, or Cook's discoveries in the South Sea, with all the warmth of a man who was to share in the honour or the profit about to accrue from them." "Dr. Hutton possessed in an eminent degree, the talents, the acquirements and the temper which entitle a man to the name of a philosopher."

Dr. Hutton's bust stands on one side of the base of the statue of Hercules, and is mounted upon a column of marble from Ipplepen, in Devonshire (No. 120).

PROFESSOR J. PLAYFAIR.—*After Sir F. Chantrey, by M. Noble.* *No.* 208.

JOHN PLAYFAIR was born at Benvie, in Forfarshire, March 10, 1748. Dr. Wilkie, the Professor of Natural Philosophy at St. Andrews, finding himself unable to discharge the duties of his office, delegated them to Playfair, then a student; a fact which proves the estimation in which he was then held. In 1773 Playfair obtained the living of Liff and Benvie, and 12 years afterwards he was appointed Professor of Mathematics, jointly with Dr. Ferguson, in the University of Edinburgh; and on the death of Mr. Robison, in 1805, he succeeded him in the chair of Natural Philosophy in that University. He was the intimate friend of Hutton and the strenuous supporter of the geological theory which bears that philosopher's name. Playfair's "Illustrations of the Huttonian Theory of the Earth," is a work justly admired for the clearance and elegance with which the system is expounded. His works were of a varied character, chiefly connected with mathematics and the higher branches of natural philosophy. The death of Professor John Playfair took place at Edinburgh on the 19th July 1819.

The bust stands on a pedestal of grey granite from the Cheesewring, in Cornwall (No. 209).

SIR JAMES HALL.—*An original bust by Patric Park.* *No.* 200.

There were few men who united with more advantage chemistry and geology than Sir James Hall, of Dunglass. At a period when the theories of the earth's formation were zealously

discussed, Sir James Hall was induced to make many experiments of a very suggestive and important character in connexion with the subject, and he may in truth be regarded as the founder of experimental geology.

The results of his investigations will be found in the Transactions of the Royal Society of Edinburgh. Sir James Hall died in 1832; and as an attentive geological observer, and a zealous chemical experimentalist, his bust finds its appropriate place with the men of his time, his friends and fellow-workers, Hutton and Playfair.

The bust is mounted on a pedestal of red serpentine from the Lizard, Cornwall (No. 201).

William Smith, LL.D.—*An original bust by M. Noble.* *No.* 111.

William Smith enjoys the distinguished merit of having been the author of the first geological map of England and Wales. He was born 23rd March 1769, at Churchill, in Oxfordshire, and died 28th August 1839, at Northampton. At an early period he was much struck with the constancy of the order of superposition of the strata, and with the characters of their organic remains. Following his occupation as a land surveyor, he travelled much; and in 1794 he was enabled, by one long journey through a great part of England and Wales, to commence his "Geological Map of England and Wales," and to draw up a "Table of the Superposition of the Strata." It was not until 1815 that those labours were fully developed, when he published a "Delineation of the Strata of England and Wales," and a memoir on the subject. In 1831 the Geological Society of London awarded to Mr. W. Smith their first Wollaston medal "in consideration of his being a great original discoverer in English geology, and especially for being the first in this country to discover and to teach the identification of strata, and to determine their succession by means of the imbedded fossils." It was in presenting this medal that Prof. Sedgwick, in an eloquent and touching address, referred to the recipient of the award as "the Father of English Geology," a title by which he has ever since been known. A memoir of William Smith was written by his nephew John Phillips, who became the distinguished Professor of Geology in the University of Oxford.

Smith's bust, which is appropriately placed opposite to that of the great geological philosopher Hutton, is mounted on a column of red marble from Kenry, in co. Limerick (No. 112).

William Buckland, D.D., F.R.S.—*A bust by H. Weekes, R.A.,* 1860. *Presented by subscription.* *No.* 5.

William Buckland was born at Axminster on the 12th March 1784. His taste for geological pursuits appears to have

been developed at an early age, for we find him when a youth at Winchester College occupied in collecting the chalk fossils of the neighbourhood, and on his subsequent removal to the University of Oxford the fossils of the oolites enabled him to pursue his favourite employment. At Oxford he attended the mineralogical lectures of Dr. Kidd, and on that gentleman's resignation in 1813 Buckland was appointed to the vacancy. About this time the importance of geological science began to be recognised at the university, and in 1819 a special readership in geology was endowed, to which Dr. Buckland was advanced. His inaugural address on this occasion was afterwards published under the title of "*Vindiciæ Geologicæ*, or the Connexion of Geology with Religion explained." A few years later he gave to the world the interesting results of his original researches on bone caverns, in the form of a treatise, entitled "*Reliquiæ Diluvianæ*, or Observations on the Organic Remains in Caves, &c. attesting the action of an universal Deluge." Some of the views there maintained he was subsequently induced to modify, as seen in his later work, the admirable Bridgewater treatise on "Geology and Mineralogy considered with reference to Natural Theology." Dr. Buckland's zeal as a practical geologist, and his ability as a writer are seen not only in these larger works, but also in the number of valuable papers which he was constantly contributing to the Geological Society. Towards the close of life, however, his mental activity declined, and after several years of retirement from geological pursuits, he expired on the 14th August 1856, having been Dean of Westminster for eleven years. A life of Dr. Buckland has recently been written by his daughter, Mrs. Gordon.

Buckland's bust stands at the head of the steps leading from the Vestibule to the Hall, opposite to that of Murchison, and is mounted on a column of pink granite from Galway, in Ireland (No. 6).

PROFESSOR SEDGWICK, LL.D., F.R.S.—*Replica of original bust by T. Woolner. Presented by the late Mrs. Elizabeth Warne. No.* 202.

ADAM SEDGWICK, Professor of Geology at Cambridge for more than half a century, was the son of the Vicar of Dent, a small town in the north-western part of Yorkshire, where he was born on March 22nd, 1785. He received his education first at Sedburgh School, and afterwards at Trinity College, Cambridge. Having distinguished himself as a high wrangler, he was appointed, in 1818, to the Woodwardian Professorship in succession to Professor Hailstone. It is the function of the Woodwardian Professor to defend the views held by the founder of the chair as to the nature and origin of fossils, but previously to Sedgwick's appointment no systematic lectures on geology had been delivered. On receiving the appointment, however, Sedgwick applied himself with characteristic earnestness to the study

of the science which was thus thrust upon him, and with such success that he was enabled, in 1820, to publish the results of some original observations on the physical structure of Devon and Cornwall. During the remainder of his days he devoted himself to the science which he thus took up, and continued as long as strength permitted, to spend his leisure time in original field-work. By his researches among the old rocks of Cumberland and North Wales he was enabled to establish his "Cambrian System." As a lecturer he exerted peculiar influence, and many of his pupils, fascinated by his enthusiasm, have become geologists of the first rank. In 1833 Sedgwick presided over the meeting of the British Association at Cambridge, and the following year he was made a canon of Norwich Cathedral. The Woodwardian Museum at Cambridge was founded by Sedgwick in 1842, and to such an extent has this magnificent collection of organic remains since grown that new buildings are about to be erected for its accommodation. Professor Sedgwick died on January 27th, 1873, and was succeeded by Mr. T. McK. Hughes, formerly of the Geological Survey.

Sedgwick's life has been written, in two volumes, by Mr. J. W. Clark and Professor Hughes.

The bust is appropriately mounted on a pedestal of encrinital limestone (No. 203) from the Yoredale series of carboniferous rocks at Dent, in Yorkshire—Sedgwick's birthplace.

George Bellas Greenough, F.R.S.—*An original bust by Neville Burnard,* 1859. *Presented by the late Miss E. M. Smedley. No.* 206.

George Bellas Greenough, the founder of the Geological Society, was born in 1778, and died at Naples in 1855. Intending to follow the legal profession, Mr. Greenough, after studying at Cambridge, proceeded to the University of Göttingen, where the attractions of Blumenbach's lectures on natural history induced him to abandon the law, and devote his energies to the pursuit of natural science. With this view he subsequently studied at the mining school of Freiberg, under the distinguished Werner, whose views he warmly espoused during the unhappy controversy between the Neptunists and Vulcanists. In the formation of the Geological Society of London, Mr. Greenough took a most active part, and, in spite of the opposition offered by the Royal Society, his exertions were rewarded by its complete organisation. As an appropriate honour to one who had steadfastly supported its foundation, Greenough was elected the first president, a position which he continued to hold for several years.

Although possessing rich stores of information, accumulated during a long and zealous life, Mr. Greenough was not a great writer; but his profound acquaintance with the sciences of geology and geography is sufficiently attested by his valuable

geological maps of England and Wales, and of India; the former published in 1819, and the latter in 1854, only one year before his death.

Greenough's bust stands on a pedestal of grey porphyritic granite from Halvasso, in Cornwall (No. 207).

PROFESSOR EDWARD FORBES.—*An original bust by I. C. Lough, 1856. Presented by subscription. No.* 204.

EDWARD FORBES was Palæontologist to the Geological Survey of the United Kingdom, and lecturer on Natural History in the Government School of Mines. He was born in the Isle of Man in 1815.

Edward Forbes was a naturalist from his childhood, always delighting in the works of creation spread around him. He spent some time at the University of Edinburgh, and in 1833 he travelled with a fellow student to Norway. Eight years after this he was appointed naturalist to a surveying expedition to the Mediterranean. With Captain Graves, in H.M.S. "Beacon," he proceeded to the scene which he marked by his important labours. In the Ægean he was enabled to determine some remarkable facts connected with animal life in the sea, and to carry out those dredging explorations which enabled him subsequently to deduce some important considerations on the distribution of animal life in space and time. During this appointment he travelled in Lycia, and fixed the sites of several of the Cibyratic cities. In 1843 Edward Forbes was appointed Professor of Botany in King's College, London. He shortly afterwards became Secretary and Curator of the Geological Society, Palæontologist to the Geological Survey, and on the organisation of the Government School of Mines, its Professor of Natural History. To the Memoirs of the Geological Survey Professor E. Forbes contributed several valuable papers; and under his care was commenced the publication of the Decades, illustrative of British organic remains.

On the death of Professor Jameson, the Regius Professor of Natural History in the University of Edinburgh, Edward Forbes was appointed to succeed him. This chair was the object of Forbes's ambition, but he was not destined long to enjoy it; he died on the 18th November 1854, only six months after his appointment.

Professor Edward Forbes's latest work, of which he left an outline sketch at the time of his death, "*On the Tertiary Fluvio-Marine Formation of the Isle of Wight,*" was completed by his colleagues, and published as one of the Memoirs of the Geological Survey. His life was written by the late Dr. George Wilson and Sir Archibald Geikie.

Professor Forbes was succeeded in the chair of Natural History in the Royal School of Mines, by the late Professor T. H. Huxley.

The bust of Forbes, which stands opposite to that of Sedgwick, is appropriately mounted on a pedestal of black marble from Castletown, in the Isle of Man (No. 205).

Professor J. B. Jukes.—*Cast from an original bust by Joseph Watkins. No.* 8.

J. Beete Jukes was one of the many Cambridge men who acquired an enthusiastic taste for geology from the spirited lectures of Professor Sedgwick. Mr. Jukes entered St. John's College in 1830, having received his previous education at the Merchant Taylors' School in Wolverhampton, and at King Edward's School in Birmingham. Anxious to make geology his profession, he accepted in 1839 an appointment in Newfoundland, and devoted two years to the exploration of the island. In 1842 he published the results of his investigations in a work entitled "Excursions in Newfoundland." Soon after his return to England he was appointed naturalist to H.M.S. "Fly." The special object of the voyage which he then undertook, under Captain Blackwood, was to survey the great series of coral reefs which form a barrier running along the north-eastern coast of Australia for upwards of a thousand miles in length. The narrative of this expedition was admirably written by Mr. Jukes. He had not been long home from this voyage before he received an appointment on the staff of the Geological Survey, with which he remained connected during the rest of his life. His work as a Government surveyor lay among the old rocks of North Wales and the coal measures of Staffordshire. A valuable memoir by Mr. Jukes on the Geology of the South Staffordshire coal-field was published in 1853. When the late Prof. Oldham left Dublin to take the superintendence of the Indian Survey, Mr. Jukes was appointed Director of the Irish branch of the Geological Survey. He was also Lecturer on Geology at the Royal College of Science in Dublin, and the author of some excellent educational works on geology. Mr. Jukes died on August 1st, 1869. His letters have been published, with a sketch of his life, by his sister Mrs. Browne.

The bust is mounted on a pedestal of red granite from Trowlesworthy, in Devonshire (No. 9).

The Ludlam Collection.

It was not originally intended that any part of the Mineral Collections of the Museum should be exhibited in the Hall; but the acquisition of the Ludlam Collection, some years ago, rendered it necessary to modify this intention, inasmuch as no other part of the Museum offered sufficient space for the reception of so large a collection. Accordingly, the visitor will now

find a number of cases of minerals exhibited in the Hall, quite distinct from the large general collection of minerals, which is displayed on the Principal Floor.

By the will of Mr. Henry Ludlam, well known for many years as one of the principal private purchasers of minerals in this country, the important collection which he had formed, at a cost, it is believed, of something like 15,000*l.* was bequeathed to this Museum. On the testator's death in 1880, the cabinets containing the collection were transferred from his residence in Piccadilly to the Museum. Eight of these cabinets are placed in the Hall, whilst three are located on the staircase leading to the Principal Floor. In order to give the visitor a general notion of the collection, about 800 of the finest specimens have been removed from the cabinets, and are displayed in six large table-cases between the columns which surround the tesselated pavement in the centre of the Hall.

The first case (No. I.) contains specimens of *Native Metals,* among which the most notable are the fine examples of *native silver* from the Kongsberg mines in Norway, and of *native gold* from Transylvania and several other well-known localities, including some fine nuggets from French Guiana. In the series illustrating *native copper* attention should be directed to a Siberian specimen with singularly well-defined cubic crystals, formerly in the cabinet of Sir Francis Chantrey. This case also contains examples of native bismuth, arsenic, antimony, tellurium, lead, and mercury, with several native alloys, such as *discrasite,* or antimonial silver, and *native amalgam.*

The next case (No. II.) is devoted to the exhibition of a series of *Native Sulphides. Zinc-blende* and *galena*—the sulphides of zinc and lead respectively—are represented by excellent specimens from several British and foreign localities; whilst the beautiful crystals of *redruthite* or *copper-glance* are characteristically Cornish. The eye, in wandering over this case, will be arrested by the magnificent crystals of *pyrite* or *iron-pyrites,* some of which are exceptional for boldness and beauty of form; and not less by the rainbow-tints of the "peacock-ore" or *copper-pyrites,* this iridescence being due to superficial tarnish. Here, too, will be found some noble crystals of *argentite,* or silver sulphide; delicate needle-like crystals of *bismuthine,* or bismuth sulphide; broad bladed forms of *antimonite* or antimony sulphide; clear crimson crystals of *cinnabar* or mercury sulphide; and fine specimens of the rare minerals *millerite* (nickel sulphide) and *greenockite* (cadmium sulphide).

At the northern end of the central area, between the busts of Sedgwick and Forbes, stand two new cases containing a selection of fine specimens from the Ludlam cabinets. The first case (No. III.) is monopolised by the single species, *fluorite* or *fluor-spar,* a fluoride of calcium remarkable for its diversity and beauty of colour not less than for its perfection of crystalline form. Specially noteworthy are some of the Cornish crystals

which exhibit, by transmitted light, an internal zoned structure of singular regularity.

The following case (No. IV.) is devoted to the natural forms of silica, including the species *quartz* and *opal*, the latter being for the most part a hydrated form of silica. Here will be found excellent examples of all the typical forms of *quartz*, such as rock-crystal, amethyst, and other siliceous minerals, some of which are strikingly beautiful in colour. A larger collection of such minerals may, however, be studied on the floor above. (*See* p. 111.)

The succeeding case (No. V.) is filled with a collection of *Native Oxides*. Ferric oxide forms a large series, including some magnificent crystals of *specular iron-ore* from Elba, remarkable for brilliancy of lustre, and in some cases for iridescence. The "rosettes," or aggregates of hexagonal plates, are characteristic of the specular iron of St. Gothard. *Magnetite*, or magnetic oxide of iron, is represented by some sharp crystals, mostly octahedra, and by a sample of "natural loadstone," bristling with the iron filings which it has attracted to its surface. Students of mineralogy will appreciate the splendid crystals of *brookite*, from North Wales, and of *anatase* from Dauphiné, which are here placed with the *rutile*, all three minerals consisting of oxide of titanium. *Cassiterite*, the chief ore of tin, is represented by a suite of crystals of singular beauty, many of them twinned, from the old tin mines of Cornwall, Saxony, and Bohemia.

The last case (No. VI.) contains selected specimens of *Native Carbonates*, commencing with some fine crystals of *cerussite*, or lead carbonate, known also as "white lead ore." Those are followed by a handsome series of the hydrated carbonates of copper, the green being known as *malachite* and the blue as *chessylite:* the former are chiefly from Siberia and Australia, the latter from Chessy, near Lyons, in France. Succeeding these are numerous specimens of ferrous carbonate, termed by mineralogists *siderite* and *chalybite*. Specialists will admire the specimens from Wheal Maudlin, in Cornwall, showing in perfection the zoned structure so characteristic of this locality. The case contains also some interesting examples of the carbonate of zinc, generally called *calamine*, principally from Vieille Montagne, between Belgium and Rhenish Prussia.

A wall-case, forming part of one of the Ludlam cabinets, standing on the western side between the pilasters numbered 139 and 142, has recently been fitted up, temporarily, with a selection of fine specimens from the groups of *phosphates*, *arsenates* and *sulphates*.

Each specimen in the Ludlam collection is distinctly labelled, and further information may be obtained on reference to the names of the several minerals in the Index at the end of this Handbook.

Building and Ornamental Stones.

The prime object originally kept in view in the arrangement of the Hall of this Museum was the exhibition of specimens illustrating the application of the rocks of the British Islands to purposes of construction and decoration. It, therefore, contains primarily a British architectural collection.

Most of the *Building Stones* are contained in a series of wall-cases erected against the western side of the Hall, near to the Jermyn Street frontage, and numbered I. to VI. These cases contain upwards of 250 specimens, uniformly dressed as six-inch cubes, and classified as limestones, dolomites and sandstones.

These specimens are chiefly those which were collected by the Commissioners appointed in 1838 to select the most durable material for the construction of the Houses of Parliament. The Commission consisted of Sir Charles Barry, Sir Henry De la Beche, Dr. William Smith, and Mr. Charles H. Smith. The physical and chemical properties of the stones were examined by the late Professor Daniell and Sir Charles Wheatstone. The specimens submitted to the Commissioners, on which they reported (*Report of Building Stone Commission*, 15*th July* 1839), were, by order of the Lords of the Treasury, placed in this Museum, and the collection has since been augmented, partly by private donations and partly by contributions from the Geological Survey.

On the opposite side is a smaller wall-case (numbered VII., VIII.) containing more than 60 cubes of unpolished granite and other crystalline rocks serviceable for construction; with which are also placed a few miscellaneous specimens. For a description of the sandstones, *see* p. 34; of the limestones, p. 30; of the dolomites, p. 33; and of the granites and elvans, pp. 16 to 21.

The *Ornamental Stones* are represented by about 270 polished specimens worked as six-inch cubes and exhibited in the table-cases (Nos. I., II., III.) on the east side of the Hall near the windows overlooking Jermyn Street. Moreover the utilisation of British rocks for decorative purposes is amply illustrated by the large number of polished columns, pedestals, vases, slabs and other objects distributed effectively about the Hall. Even the walls are so decorated as to show the value of our native rocks for the artistic covering of mural surfaces.

The wall-space on the eastern side of the Hall is decorated with a screen (A.) extending from the southern end to pilaster No. 30. In this screen designed by Mr. Charles F. Reeks, the central panels are of Ballinahinch serpentinous marble, surrounded by grey Derbyshire marble, with running borders of guilloche and fretwork, the former of red Staffordshire marble and Derbyshire anhydrite, the latter of similar red marble and Derbyshire stalagmite. The pilasters and architrave are of Lizard serpentine, whilst the base is of russet and bird's-eye marble from Derbyshire.

The screen (B.) between pilasters Nos. 30 and 42 exhibits a large central panel of marble from the Mumbles, Swansea, the smaller panels being of Ipplepen marble, Devon; while the cornice is of Lizard serpentine, and the remainder of Derbyshire marbles.

In screen (C.) occupying the space between pilasters Nos. 42 and 46 the circular centre is of Derbyshire rosewood marble, and the remaining panels of crinoid, coral, and other varieties of Derbyshire marble, whilst the ground in which the whole is inlaid is of Fauld alabaster, and the base of reddish hornblende-granite from Mount Sorrel, Leicestershire.

Scotch granites and marbles occupy the screen (D.) in the wall-space between pilasters Nos. 46 and 50. On the base of grey granite from Kemnay (Aberdeenshire) rests a moulding of red Corrennie granite, above which is a dado of grey granite from Cairngall, near Peterhead, surmounted by a cornice of pink granite from the Isle of Mull. In the upper part the ground is of red granite from the Stirling Hill quarries, near Peterhead, whilst the central circular panel is of Strathdon marble (Aberdeenshire), and on each side of this is a panel of hornblendic porphyrite from Mayon, near Huntly, Aberdeenshire. The remaining panels, which in most cases correspond on opposite sides, are, commencing from below, of Kingswell porphyry (Aberdeenshire); Glen Tilt marble (Perthshire); Sutherlandshire marble on the left hand, and Portsoy serpentine on the right; Tiree marble, Hebrides; and Rubislaw granite, Aberdeenshire.

The granites are described below. For a description of marbles, *see* p. 22; of the alabaster, p. 28; and of the serpentine, also p. 28.

While examining the contents of the Hall it should be borne in mind that the main object of this section of the museum is almost purely technological, and hence the geological student who wishes to study the physical characters of our rocks rather than their industrial uses must be referred to the series of British rock specimens in the Petrographical Room on the Upper Floor (p. 149).

Granite.

This rock, in its typical varieties, is a crystalline aggregate of the three minerals, *felspar* (p. 115), *quartz* (p. 111), and *mica* (p. 117). The felspar, which usually forms the chief constituent, is in most cases the common potash-felspar called *orthoclase;* but this is frequently associated with other species, such as *microcline, albite,* and *oligoclase.* The orthoclase often occurs in large well-formed crystals embedded in a fine-grained base, thus producing the beautiful *porphyritic granites,* or *granite-porphyries,* of which some fine examples are exhibited (p. 21). Sometimes two kinds of mica are present, one being a pale silvery mineral called *muscovite,* while the other is the dark brownish-black mica termed *biotite* (p. 117). A practice has lately grown up, following German precedents, of calling a biotite-granite, or

granite which contains only dark mica, a *granitite*. *Hornblende* is not infrequent either as an accessory constituent, or replacing the biotite, and the rock is then distinguished as a *hornblende-granite*.

Certain varieties of granite rather rapidly suffer disintegration on exposure, but most granites are remarkable for their extreme durability. Combined with a considerable degree of hardness, this durability renders granite highly valuable as a building stone for bridges and other massive structures, while the toughness of the hornblendic varieties makes them especially suitable for road materials. At the same time the beauty of many granites, and the high polish which their hardness renders them capable of receiving, recommend their use for purposes of ornament. The industrial applications of granite are, however, restricted by the expense of working so hard a stone.

GRANITES OF CORNWALL AND DEVONSHIRE.—*Pedestals and Columns Nos.* 9, 61, 63, 72, 75, 78, 81, 85, 176, 180, 207, *and* 209. *Cubes in Table Case III. and Wall Cases VII. and VIII.*

The principal exposures of granitic rocks in England are in the counties of Cornwall and Devon, where five large areas occur, with a few smaller outlying masses. These districts form high ground, rising like islands of granite from the surrounding killas or clay-slate. The five principal areas are known, proceeding from east to west, as Dartmoor, Brown Willy or St. Breward granite, Hensbarrow or St. Austell granite, Carn Menelez or Penryn granite, and the Land's End or Penzance granite; whilst still more westerly are the exposures of granite in the Scilly Islands. Lundy Island, in the Bristol Channel, is also composed of granite.

Most of the West of England granites are coarse grained, and even porphyritic in texture. Their prevailing colour is grey, but red granite is not unknown, as seen in the handsome rock from Trowlesworthy on Dartmoor (No. 9). In some of the granites of Cornwall and Devon, the felspar passes into kaolin or china-clay; this is especially the case on the southern margin of Dartmoor; in the neighbourhood of St. Austell; and at Breague, near Helston, in Cornwall. Schorl, or black tourmaline, is not unfrequently present as an accessory constituent, especially on the margin of an intrusive boss of granite.

The following great works, amongst many others, have been constructed entirely or in part of Cornish granites: The Penryn and Lamorna granites have been used in Portland breakwater; Keyham Docks, Devon; Commercial Docks, London; the Hull, Great Western, and Birkenhead Docks, and the National Works at Chatham and Portsmouth, together with the Scutari monument. The plinth for the railings of the British Museum is from the Carnsew Quarries, near Penryn; and the towers,

including the lodge for gates, &c., from Constantine. The Constantine granite was used for the Wellington Memorial at Strathfieldsaye, the shaft of the column being a monolith 30 feet in height.

The Cheesewring granite has been used in the London Docks, Westminster Bridge, the Thames Embankment, Rochester Bridge, the docks at Copenhagen, the Great Basses Lighthouse, near the island of Ceylon, and for the tomb of the Duke of Wellington in the crypt of St. Paul's Cathedral. The De Lank or Eddystone Quarries, near Bodmin, furnished the stone for the New Eddystone Lighthouse, and for works at Blackfriars Bridge and elsewhere.

Cornish granites are exhibited from the following localities:—Lamorna Cove, Paul, Castle-an-Dinas, Marazion, Madron, Ludgvan, Constantine, Carnsew, Mabe, Penryn, St. Austell, St. Blazey, Lanlivery, Luxullian, Roache, Lanivet, Withiel, Bodmin, Castle Quarry, St. Breward, Cardynham, St. Neots, Trewoon, Halvasso, and the Cheesewring.

Devonshire granites are exhibited from the Fremator quarries, near Tavistock, and from Blackenstone, Haytor, and Trowlesworthy on Dartmoor. The Haytor quarries, on Dartmoor, supplied the granite for a great part of London Bridge.

In addition to the granites from our western counties noticed above, a few other specimens are exhibited from localities of much less importance. *Shapfell*, in Westmoreland, furnishes a beautiful porphyritic granite represented by the Column No. 188, and by the plinth of the pedestal which supports the bust of Prof. Sedgwick. The Shap granite, with large salmon-coloured crystals of orthoclase, has been extensively employed of late years in London, and fine polished examples may be seen in the posts around St. Paul's Cathedral; in the columns of the Midland Railway Terminus, St. Pancras; and in the Temple Bar memorial.

Mount Sorrel, near Charnwood Forest in Leicestershire, yields a pink hornblende-granite, which has been employed in the decoration of the eastern wall; and a grey granite from this locality is represented by some polished cubes. The base of the pedestal No. 205 is from the boss of granite which penetrates the surrounding schists on the south-eastern side of South Barrule, one of the highest points of the *Isle of Man*. The granite of *Lundy Island* is represented by several cubes in Cases III. and VII.

From the *Channel Islands*, especially from Guernsey, large quantities of granite, mostly hornblendic, are exported, chiefly for use in London and elsewhere, as road-metal, pitching, and kerb-stones. Specimens are exhibited in the table-cases from the quarries of Mount Mado and La Perruque in Jersey, and from Guernsey and its dependency, the little island of Herm.

GRANITES OF SCOTLAND.—*Steps at Entrance. Pilasters Nos.* 7, 146, 197. *Pedestals, Columns, &c., Nos.* 2, 4, 127, 133, 160, 172, 174, 182, 190, *and* 196. *Cubes in Table Case III. and Wall Cases VII. and VIII.*

Granitic rocks are extensively developed in Scotland, especially in the Central Highlands, where they form some of the highest mountains of the Grampian range; but for industrial purposes those only are important which are so situated as to be readily accessible and advantageously worked. The quarries in Aberdeenshire, which are among the oldest and most important in the country, are in two separate granitic areas—one in the district of Aberdeen, and the other farther to the north, in the district of Peterhead.

The granite of Aberdeen, especially that from the quarries of Rubislaw, Dancing-Cairns and Tyrebagger, is much used in the metropolis for kerb and paving stones. The Kemnay quarries, about 17 miles N.W. of Aberdeen, yield a rather coarse greyish granite, which has been employed in the construction of docks at many northern ports, as also in the piers of the Forth Bridge. The usual colour of Aberdeen granite is grey, but some red and pink granite is also quarried locally, as at Correnie Hill, where a handsome salmon-coloured rock is worked (No. 182). Around Peterhead, the red granite prevails; hence it is usually distinguished as *Peterhead granite*. The principal quarries are those of Stirling Hill, Longhaven, and Cairngall. The Sheerness Docks were built mostly with stone from these quarries. The Stirling Hill quarries, at Boddam, furnished the pillar of the Duke of York's monument, and the Seafield quarries the abacus. The beautiful pillars in the library of the British Museum were obtained from Longhaven; the cost for transport at the time they were worked being enormous. The pillars in the Fishmongers' Hall are from the Stirling Hill quarries, as are also the bases of the monuments of Pitt and Fox; while the polished pillars of the Carlton Club house are from the quarries near Peterhead. The Cairngall grey granite forms the basins of the fountains in Trafalgar Square; and it was also used for the Prince Consort's sarcophagus.

The fine pink and red granites of the Isle of Mull have been largely worked, and were employed in the erection of the Albert Memorial in Hyde Park. Mull granite was also used in Westminster and Blackfriars Bridges, and in the Holborn Viaduct.

Several masses of granite are exposed as protrusions among the slaty rocks of the Southern Uplands of Scotland. The grey granite of Dalbeattie, in Kirkcudbrightshire, has been largely employed as a building material in Manchester, Liverpool, and other towns, and for the construction of docks at Liverpool, Birkenhead, and Swansea.

Specimens of Scotch granites are exhibited from the following localities:—Peterhead, Aberdeen, and Corrennie Hill, Aberdeen-

shire; Portsoy, Banffshire; Dalmore, Sutherland; Oban and Mull, Argyleshire; Tiree, Hebrides; and Craignair, Kirkcudbrightshire.

Granites of Ireland.—*Base of Sides in Vestibule. Column, No. 6. Cubes in Table Case III.*

The granite rocks of Ireland occur in four districts, namely, in Wicklow and Wexford, in the south-east; in Down and Armagh, in the north-east; in Donegal, in the north-west; and in Galway and Mayo, in the west.

The most extensive granite district in Ireland, and indeed in the whole of the British Islands, stretches south from Dublin, through the counties of Wicklow and Carlow into Kilkenny and Wexford, occupying an area 70 miles in length, and from 7 to 17 miles in width. The granite of the Wicklow range is the most extensively used. It varies in its quality, that near Kingstown being coarse and hard, while that from Ballyknockin or Golden Hill is much finer, and therefore fitted for ornamental work.

The Dalkey quarries, at Killiney, near Dublin, yielded enormous quantities for the harbour and pier of Kingstown, and for numerous buildings in and around Dublin. It has also been employed in the Thames Embankment.

Passing to the north-east of Ireland we find granitic rocks, forming three distinct tracts in the mountain ranges of Mourne, of Carlingford, and of Slieve Croob. The granite of Newry has been extensively quarried, and sent by water to the north of Ireland, and elsewhere. The Bessbrook quarries, near Newry, yield a well-known grey granite. A quarry at Ballymagreehan, near Castlewellan, yielded much of the granite used for the base, the pedestal, and steps of the Albert Memorial in Hyde Park.

In Galway at least two varieties of granites have been recognised, but the characteristic Galway granite is a handsome porphyritic rock with large crystals of red orthoclase. This rock has been quarried at Furbogh, eight miles from Galway, and a column (No. 6), showing the appearance of the granite when polished, will be found in the Hall. The granites of Donegal have never been worked on a large scale.

The following Irish localities are represented in the collection:—Kingstown, Killiney, Dalkey, Kilgobbin, and Glencullen, co. Dublin; Glenaree and Ballyknockin, co. Wicklow; Ballyholland, near Newry, co. Down; and Galway.

Porphyries. Elvans. Greenstone.

Under the common term of *Porphyry* are sometimes grouped together all rocks in which distinct crystals are embedded in a finer-grained ground-mass; the term thus referring rather to the physical structure of the rock than to any more essential

character, and hence embracing many kinds which in chemical composition are widely distinct. It is convenient, however, to restrict the term *porphyry* to acid porphyritic rocks, containing orthoclase-felspar, and to apply the term *porphyrite* to basic rocks, of similar texture, with plagioclase-felspar. The ancient red porphyry of Jebel Duchan in Egypt, which, from its purple colour, originally gave its name to this group of rocks, is a hornblende-porphyrite. The ancient green porphyry of Greece, with large pale green crystals of plagioclase, is technically a diabase-porphyrite; and the green porphyritic rock of Lambay Island, near Dublin, represented by the cube No. 77, is of similar character.

Many of the Cornish and Devon granites in the collection are eminently porphyritic, and we may especially notice the pedestals and columns Nos. 61, 75, and 176.

The sarcophagus for the Duke of Wellington, in St. Paul's, is formed of one huge mass, of the same character as the red and black variety in the column No. 170, and in the bases of the pedestals Nos. 75 and 81. This beautiful rock, which, from its locality, has been called by Prof. Bonney *Luxullianite*, consists of large crystals of pink orthoclase-felspar, in a dark ground-mass of schorl, or black tourmaline, with a small proportion of quartz.

Upon reference to a geological map of Cornwall a number of bands will be seen traversing both the granite and slate rocks, and having a main general direction from the north of east to to the south of west. These represent dykes of what is locally termed *Elvan*. The miners include under this name a great variety of rocks, some of which resemble fine-grained granites, with little or no mica (*microgranite*). Frequently the elvans become porphyritic, being chiefly composed of a fine felspathic or quartzo-felspathic base, containing crystals of felspar and quartz, sometimes with schorl and occasionally, though rarely, mica. Such rocks pass under the names of *quartz-porphyry* and *quartz-felsite*, in allusion to the presence of porphyritic crystals of quartz, often bi-pyramidal and sometimes so rounded as to appear as mere blebs; while if felspar only be present as the porphyritic constituent, the elvan becomes a *felspar-porphyry*.

Sir Henry De la Beche remarks of the Cornish elvans: "For durable stone the harder elvans of this district, particularly when of good cream and other light colours, may be considered as the best building materials in it: their durability and appearance may be seen in many churches and old mansions, where the finer carvings of the ornamental parts are as sharp as the day they were put up."

In the Table Case III. and in the Wall Cases, Nos. VII. and VIII., will be found specimens of elvans from Mayen, Land's End; Marazion, near Penzance; Breague, near Helston; Porkellis, Wendron; Roscrow and Trevailes, Penryn; Newhaven, Truro; near Newquay; Pentuan, and Dowgas Mine, St. Austell;

Withiel, Lanivet, St. Neots, and Tremore, near Bodmin; St. Dennis; Camelford; and Meldon, Okehampton, Devon.

The term "Greenstone" has been rather loosely applied to many igneous rocks, which have acquired a dark green tint as a result of the alteration of some of the mineral constituents, and the consequent formation of chloritic products. Some of these greenstones should be technically termed *diabase* and others *diorite.* A diabase is an altered basic rock, which originally contained plagioclase and augite; whilst a diorite is a less basic rock, containing plagioclase and hornblende, or some other ferro-magnesian silicate, often associated with free quartz. The polished bust of Bubastis (No. 132), placed near the western entrance to the theatre, was skilfully carved, after an Egyptian statue in the British Museum, by the late Mr. C. H. Smith, in a diabase from Llanwnda, near Fishguard, in Pembrokeshire. The well-known Pen-maen-mawr stone (No. 151, beneath Case VII.), which occurs as an intrusive mass near Conway, in Carnarvonshire, and from its toughness forms a valuable paving material, is petrographically an enstatite-diorite; enstatite being the name given to a rhombic pyroxene.

The rocks called *syenite* contain orthoclase-felspar associated with hornblende, or rarely with some other ferro-magnesian mineral, such as augite or biotite; and hence syenite differs from diorite mainly in the character of its felspathic constituent. The word is derived from Syene, the ancient name of Assouan in Upper Egypt, where a granite containing hornblende and biotite was quarried; and it was formerly the practice to refer to hornblende-granites as syenitic rocks. True syenite is by no means a common rock in Britain, and is not used as an ornamental stone.

Marble.

It is a common practice to comprehend under the name of *marble* most stones which are capable of receiving a polish and of being applied to purposes of decoration, the term being thus made to include such substances as serpentines, porphyries, alabasters, and other ornamental stones. It is convenient, however, to limit the term to those varieties of limestone which are sufficiently hard and compact to be susceptible of polish and of application to ornamental uses. A typical marble is an aggregate of granular crystals of calcite.

Although by no means restricted to any particular strata, yet the marbles of this country are usually obtained from the palæozoic rocks, being especially abundant in the Carboniferous and Devonian systems. The Carboniferous or Mountain Limestone—which runs round the margin of many of our coal-fields, and rises in our northern counties as a broad ridge or anticlinal curve forming the Pennine chain—furnishes valuable marbles in certain districts, especially in Derbyshire and on the borders of

Staffordshire; whilst the fossiliferous limestones of the Devonian system—still older than those of the Carboniferous series—yield the valuable marbles of South Devon.

Derbyshire Marbles.—*Pilaster,* 136. *Columns, &c., Nos.* 31, 47, 57, 58, 65, 68, 69, 93, 94, 96, 97, 108, 110, 113, 118, 122, 124, 125, 135, 138 141, 156, 168, 173, *and* 192. *Tazze, &c., Nos.* 66, 70, 74, 80, 107, 109, 121, 123, 187, *and* 189. *Inlaid Work, Nos.* 145 *and* 161. *Cubes in Case I.*

The rocks of Derbyshire are rich in ornamental marbles, which, from their beauty, and in many respects their curious characters, have been largely employed for decorative purposes. They are usually distinguished by their colour—as grey, dove, black, rosewood, and russet marbles; or by physical peculiarities, dependent mostly upon their fossil contents, as bird's-eye, dog-tooth or mussel, entrochal, coral, shelly, and breccia marbles. The limestone of Derbyshire forms a very thick mass divided by thin partings of shale, and by the igneous rocks called *toadstone*—said to be a corruption of the German *Todtstein,* or "dead stone," in allusion to these trap rocks being usually barren of lead ore compared with the adjacent limestones. The toadstone consists of doleritic and basaltic lavas, in some places amygdaloidal and often more or less altered into diabase, and associated locally with volcanic tuffs.

Among the ornamental marbles of Derbyshire is the well-known *crinoidal* or *encrinital* marble, so called from the presence of abundant fossil remains of encrinites, or "stone lilies." These were echinoderms belonging to the Crinoidea—a group of which there were formerly but few living representatives known, compared with the abundance which existed in the Palæozoic and Secondary periods. The beautifully-formed and numerously-jointed *Pentacrinus caput-Medusæ,* which is occasionally dredged from great depths near the West India Islands, is one of the finest living examples of this class; but a rich diversity of forms has been discovered in recent years by the Challenger and other exploring expeditions. The encrinite consisted of a long jointed column attached by one extremity to the sea-bottom, and supporting at the opposite extremity a cup-shaped body, from which radiated several articulated arms furnished with ciliated appendages. The entire structure was rendered flexible by the internal calcareous skeleton being composed of numerous bead-like joints. The dislocated fragments, or joints, are cemented together, in the marble, by means of carbonate of lime; and being, in the process of manufacture, cut in many different directions, assume a variety of forms. Many beautiful examples of these crinoid marbles will be found in the collection. The perforations in the centre of the joints afford facilities for stringing them as beads; in this way these fossils were used as rosaries, and they are still known in northern England as "St. Cuthbert's beads."

The shell-marbles usually contain the remains of *Brachiopoda*, organisms which are so called from having two long ciliated "arms" (*brachion Gr.*, an arm; *pous*, a foot). These are "shell-fish," furnished with two valves which are never quite equal, but since each valve is equal-sided the forms are symmetrical. In these points they differ from the ordinary bivalves, or true molluscs, which are mostly equivalved but rarely quite equilateral. From the resemblance of certain brachiopod shells to antique lamps, they are commonly called "lamp shells;" the hole corresponding to that which in a lamp admits the wick, serves in the lamp shell for the passage of the pedicle by which the animal attaches itself to submarine objects. *Spirifera* and *Productus*, two genera of the above class, are the most abundant in these limestones.

The black marble is a bituminous limestone, found especially in descending into Monsal Dale from Little Longsdon. Machinery for cutting and polishing this marble was first used at Ashford in the year 1748, and marble works are still in operation in this locality.

In this collection the following localities of Derbyshire marbles are represented, viz.,—Wirksworth, Middleton, Bonsall, Matlock, Nether Haddon, Allport, Monyash, Oneash, Sheldon, Ashford, Flagg, Stony Middleton, Buxton, Miller's Dale, Ricklow Dale, and Tideswell.

A cube of crinoidal marble, extremely similar to some of the Derbyshire marble, from the Yoredale rocks (Lower Carboniferous) of Dent, in the west of Yorkshire, is placed with the specimens from Derbyshire in Case I. As Dent was the birthplace of Professor Sedgwick a pedestal of this marble has been selected as an appropriate support to the bust of this distinguished geologist. (No. 203.)

STAFFORDSHIRE MARBLES.—*Columns, &c., Nos.* 129 and 186. *Tazza* 64. *Inlaid work*, 145 *and* 161. *Cubes in Case II.*

The marbles in Staffordshire present but little variation from those of Derbyshire, the adjoining county. Their geological positions are the same, and they present similar general characters. Specimens of Staffordshire marbles are exhibited from Wetton and from Ecton.

The variety of coloured marbles which the two counties of Derbyshire and Staffordshire produce has led to the manufacture of mosaic work of a very beautiful description. Indeed, some of the inlaid tables, tazze, and other marble ornaments, may not unworthily be compared with the far-famed Florentine mosaic work. In addition to the inlaid tables in this Hall, there will be found some interesting specimens of this kind of work in the horse-shoe case on the principal floor.

Devonshire Marbles. — *Pilasters,* 46 *and* 139. *Screen B, Columns, Slabs, &c., Nos.* 10, 43, 61, 63, 102, 120, 154, 193 and 194. *Inlaid Table,* 163. *Cubes in Case I.*

The limestone formations of Devonshire, from which ornamental marbles are obtained, may be said to be confined to the districts extending from Torbay to a few miles beyond Newton Abbott and Totnes, and to the neighbourhood of Plymouth. These limestones, often united under the general term of the "Great Devon Limestone," belong to the group of strata known to geologists as the *Devonian system*, and are placed in that section which is recognized as *Middle Devonian*. The limestones, of the Carboniferous series of North Devon are rarely worked for ornamental purposes.

Marble works have been extensively carried on at St. Mary Church near Torquay, the Babbacombe limestones yielding some interesting varieties of the red, grey, and variegated marbles. Many bands are almost entirely formed of fossil corals, and are consequently known as *madrepore marbles;* it has often been suggested that the origin of both the Torquay and Plymouth marbles may have been of an analogous character to that of the coral formations now taking place in the Pacific and Indian Oceans. The "Buck's-horn marble" or "Feather stone," owes its peculiar character to the presence of a coral usually called *Favosites cervicornis*. Crinoids, brachiopods, and other fossils are also common in the Great Devon Limestone.

At Ipplepen there is an extremely handsome variety of a reddish marble, and some of a nearly similar character occurs near Totnes. The limestones of Plymouth are not generally so handsome as those of Babbacombe, but many very fine examples may be obtained. The quarries of Oreston, near Plymouth, furnished the stone employed in the construction of the Plymouth breakwater, and in connexion with the use of this limestone for that purpose, one curious circumstance attracted attention. Between high and low water marks the boring molluscs (*Pholas dactylus*) so perforated the limestones that it was found necessary to replace them by blocks of granite, which, being much harder than the shells of these animals, resists their action.

Devonshire marbles are exhibited from Babbacombe, Bradley, Ipplepen, Buckfastleigh, Ogwell, Chudleigh, Kitley Park, and Plymouth.

The large round table in the Hall (No. 163), inlaid with marbles which are solely the productions of Devonshire, is interesting as an illustration of the remarkable variety of ornamental stones yielded by this county.

Marbles of Bristol, Isle of Man, &c.—*Columns, &c.,* 16, 158, 205. *Cubes in Case II.*

The Bristol marbles, like those of Derbyshire, but unlike those of Devonshire, belong to the Carboniferous formation.

The rocks which rise on the banks of the Avon have been always celebrated for their picturesque character, this feature being dependent not only upon their bold outlines, but upon their varied colours and irregular forms. Several varieties of ornamental marbles are exhibited from the rocks of this district, especially from the limestone of Clifton. Like those already described, these marbles are fossiliferous; crinoids are common, fish-palates occur in some, and many of the beds are rich in corals.

Among the British marbles in Case II. will be found a specimen of the argillaceous limestone commonly called "*Landscape marble*," in allusion to the peculiar dendritic markings which it exhibits. It occurs in the Penarth or Rhætic beds (p. 153), especially in the neighbourhood of Bristol; and is sometimes used, under the name of Cotham marble, for the manufacture of small ornaments. The *Ammonite marble* (No. 17), from the Lower Lias of Marston near Yeovil, takes its peculiar character from the vast numbers of ammonites which it contains; these fossils, somewhat resembling the shells of the living nautilus, will be noticed in another place (p. 145).

Attention may here be directed to the specimens of conglomerate from Glamorganshire (Nos. 15 and 83), which belongs to the New Red Sandstone series, and rests frequently on the upturned and denuded edges of the older strata. The fragments forming the conglomerate or "pudding stone" have been derived, to a large extent, from the Carboniferous Limestone, and are united by a cement sometimes calcareous, but usually magnesio-calcareous or dolomitic. A fine slab of this *dolomitic conglomerate* is exhibited from Draycot, near Wells (No. 15). With these dolomitic conglomerates may be noticed some specimens of the peculiar *breccia-marble* of the Isle of Man (No. 22). The black marble from the Carboniferous Limestone of the Isle of Man has been selected as an appropriate material for the pedestal (No. 205) supporting the bust of Professor Edward Forbes, who was a native of the island.

In Case II. will also be found a few other marbles of less importance than those already noticed. These are from Somersetshire, Herefordshire, and South Wales. The Carboniferous Limestone of the Isle of Anglesey has furnished the black marble employed for the columns Nos. 16 and 158.

At the entrance to the Geological Survey Office is a slab of dark brown limestone, rich in corals, from the Yoredale strata of Frosterley, near Stanhope, in Weardale, Durham (No. 144). This marble has been used for columns in Durham Cathedral.

IRISH MARBLES.—*Pilaster* 50. *Columns, &c.* 41, 67, 73, 112, 114, 140, *and* 171. *Cubes in Case II.*

Ireland is rich in marbles; indeed in no other part of the British Islands is the Carboniferous Limestone developed on so grand a scale. Extending over a great central plain, 120 miles

from Dublin to Galway Bay, and about the same distance north and south, it forms the characteristic rock throughout the greater part of the island, and attains in the southern counties the prodigious thickness of nearly 3,000 feet. The more valuable quarries are in the counties of Kilkenny, Carlow, Galway, and Mayo; from these several varieties of marbles are raised, especially, the black marble, next to which in importance are the dove, mottled, grey, red and white marbles. The Galway marbles are well known, but the beds in the quarries are usually thin: the best stratum is known locally as "the London bed." The marble is quarried principally at Menlo, on the banks of Lough Corrib. The black marble of Kilkenny, like many others, owes its colour to the presence of organic matter, and as this gradually becomes altered by exposure to the atmosphere the colour may deteriorate. The "shelly black" of Kilkenny is a well-known marble. The red marbles of Limerick, Clare and Cork, include some beautiful varieties which have acquired considerable repute. White marble is obtained from the rocks of Connemara and Donegal; the limestone of the former district is hard, strong and fine grained, while that of the latter is generally too coarse for fine work. The white Connemara marble cannot, however, be procured in large blocks free from streaks which pass through the blocks parallel with the beds.

Black marble is principally obtained from Kilkenny, Galway, Churchtown, Donerail, Kerry, and Tipperary; *white* marble from Connemara, Donegal, Churchtown, and Kerry; and *coloured* marbles are scattered over all the districts in which the limestones occur, the *reddish* varieties being found principally near Armagh; in the south of Clare; in the county of Limerick; and at Middleton and Churchtown in co. Cork. The *sienna marble* comes chiefly from King's co.

The serpentinous marble, or ophicalcite, of Connemara will be noticed at p. 29.

Irish marbles are exhibited from Clonony, King's co.; Phœnix Park and Finglass, Dublin; Mitchelstown, Cork; Kenry and Askeaton, Limerick; Minto, Galway; Ballinahinch; the Twelve Pin Mountains; and Rossvella and White Craig Quarries.

Scotch Marbles.—*Screen D. Cubes in Cases II. and III.*

An interesting variety of marble is exhibited from Tiree, in the Hebrides, where it occurs associated with the archæan gneiss. The marble consists of a base of pink limestone, through which are disseminated granular masses of a dark green augitic mineral, giving the stone a porphyritic appearance. The bust of of Sir H. T. De la Beche in the library of this institution is supported on a fine block of this marble.

Alabaster.

Sides of Vestibule. Screen C. Columns, &c., Nos. 79, 88, 92, 137 *and* 143.

The term *alabaster* was formerly applied to a stalagmitic variety of carbonate of lime much used by the ancients for ornamental purposes, especially for the manufacture of small vases for holding precious ointments; whence such vessels received the name of "alabastra." This *Oriental alabaster*, of which the Algerian "onyx-marble" is a modern example (*see also* the slabs, Nos. 21, 24, 25), must be distinguished from the mineral which is at present called alabaster; that name being now applied to the fine massive or granular-crystalline varieties of *gypsum* (p. 109). This mineral, which occurs abundantly in the form of nodules, bands, and veins, in the New Red or Keuper marls of our Midland counties, is a hydrous sulphate of lime, containing, when pure, sulphuric acid 46·51, lime 32·56, water 20·93. Owing to the presence of oxide of iron and other impurities, the mineral is rarely uniform in tint, but is generally clouded and streaked with red, as seen in the specimens exhibited. These are from Fauld, in Staffordshire; and Chellaston Hill, near Ashbourne, in Derbyshire. Alabaster likewise occurs near Newark, in Nottinghamshire; near Watchet, in Somersetshire; and elsewhere in Triassic marls; whilst it is found in Purbeck strata near Battle, in Sussex, and at Swanage in the Isle of Purbeck.

There is much demand for alabaster by the potters in Staffordshire, who form their moulds of plaster of Paris from it, whence it has been called *potter's stone.* In working the stone the fine blocks are selected, and sold to the turners of alabaster ornaments. No. 79 is an illustration of the process of working this material for ornamental purposes. It is now largely used for internal ecclesiastical decoration.

Several varieties of alabaster occurring in the province of Pisa in Italy are extensively worked into ornamental objects, and as the stone is extremely soft, the cost of working is but small, and alabaster ornaments are therefore imported into this country at a very low price. The purest white alabaster is worked by underground excavations in the Val di Marmolaio near Castellina, 25 miles from Volterra, in Tuscany.

Serpentine.

Cornish Serpentines.—*Screen A. Slabs, Columns, Tazze, &c., Nos.* 51, 60, 128, 130, 131, 164, 166, 167, 175, 177, 178, 179, 191, *and* 201. *Cubes in Case III.*

The Serpentine,—so called from the supposed resemblance of the rock to the skin of a serpent,—which is found in quantity at the Lizard, is undoubtedly the most beautiful of the

ornamental stones of this country. The variegated colours on which its elegance depends, are usually dark rich shades of red and green, irregularly mingled, and often relieved by white veins of *steatite* or soap-stone. Near to, and to the eastward of, Cadgwith a very beautiful variety of reddish serpentine occurs, studded with brilliant laminæ of *bastite*, a hydrous silicate of magnesia and iron, known also as *Schiller spar*. Both the serpentine and the associated steatite are essentially hydrous silicates of magnesia, the former usually containing more or less iron. Serpentine is in most cases a product of the alteration of rocks rich in olivine—a silicate of magnesia and iron—but it may also result from the alteration of augitic and hornblendic rocks.

For purposes of ornament this elegant stone is well adapted, being moderately soft, but not brittle, and therefore, easily worked, while it is sufficiently hard to receive an excellent polish. There are few spots around the British coast more beautiful and grand than Kynance Cove near the Lizard, where the serpentine rock in all its varied dyes, is polished by the beat of the Atlantic waves, and, in contrast with the white sands of the shore, is rendered still more striking and characteristic.

Formerly the steatite, from the "Soap Stone Rock," near Mullion, was sent in considerable quantities to Bristol, where it was used in the manufacture of carbonate of magnesia; and at one period it was employed at Worcester in the manufacture of porcelain, but it is no longer worked for either purpose.

IRISH SERPENTINES.—*Screen A. Pilasters Nos.* 42 *and* 142. *Slabs, Columns, &c.*, 20, 82, 91, 185, *and* 199.

Serpentine frequently occurs in intimate association with limestone, forming a mixed rock, often of great beauty, known generally as *ophicalcite*. The celebrated *vert antique*, or the *verde antico* of the Italians, is a rock of this kind. Somewhat similar serpentinous marbles occur in Ireland, especially in Galway and Donegal, which afford beautifully variegated green and white specimens. The green Connemara marble, known to architects as "Irish Green," is obtained at Ballinahinch, Letterfrack, and other localities in Galway, the most valuable quarries being situated near Clifden, whence this material is exported. A very fine slab (No. 20) is exhibited from Lissoughter. It should be remembered that ophicalcite is not suited for outdoor work in this climate.

ANGLESEY SERPENTINE.—*Pedestal No.* 14.

Among the ancient rocks of Anglesey a greenish serpentine occurs at several localities, frequently associated with limestone. An example of this green serpentinous marble is furnished by the pedestal before us, from Rhôscolyn near Holyhead.

Scotch Serpentines.—*Obelisk No.* 155. *Cubes Nos.* 13 *and* 165.

Serpentine rocks occur in various localities in Scotland, especially in Banffshire and Aberdeenshire, and again in the Shetland Isles, where they form the matrix of the chrome iron ore. As will be seen from the specimens, very fine varieties for ornamental purposes are obtained from Portsoy, on the north coast of Banffshire, whence this elegant material was formerly exported.

Limestones.—*Cubes in Wall Cases I., II., and III. Copy of the Farnese Hercules in Portland Stone, No.* 116.

A large number of limestones from widely different localities, are here gathered together, and arranged in stratigraphical sequence. Most of these are derived from Jurassic rocks, since palæozoic limestones are, for the most part, sufficiently indurated and compact to receive a polish, and may therefore be classed as marbles rather than as ordinary limestones; whilst on the other hand, the limestones of our Upper Cretaceous and Tertiary formations are usually ill-fitted for building purposes. Chalk, however, is rather largely employed in certain districts, and specimens from the Middle Chalk of Beer, near Seaton, in the south east of Devonshire are here exhibited. Beer freestone was employed in Exeter Cathedral and many other edifices, and its use has recently been extended, chiefly for inside work.

The *Totternhoe stone*, so called from a locality near Dunstable, is a soft sandy limestone, from the Lower Chalk, which being easily worked has found favour locally and is used as a building material in Bedfordshire and Cambridgeshire.

The *Kentish rag*, of which a specimen is exhibited from the Iguanodon Quarry, near Maidstone, is a hard siliceous limestone from the Hythe beds of the Lower Greensand, where it occurs associated with a soft calcareous sandstone known locally as "hassock." The rag stone is extensively used for building purposes.

From the Purbeck beds, which are mostly of freshwater formation and serve to connect the Wealden beds above with the Oolites below, are obtained many limestones which have long been worked as building stones. Several specimens are exhibited, mostly from Swanage in that part of Dorsetshire, known as the "Isle" of Purbeck. From the upper beds of the Purbeck group is obtained a compact shelly fresh-water limestone known as *Purbeck marble*, of which a polished cube is exhibited in Table-case II. The marble abounds in organic remains, and indeed is for the most part a congeries of fresh-water shells (*Paludina*). It occurs in beds which vary in thickness from six to nine inches, and it was much employed in this country as far back as the thirteenth century, especially for the slender shafts in cathedrals.

but the introduction of foreign marbles has occasioned its use to be almost discontinued. Very similar to this Purbeck marble are certain fresh-water limestones abounding with *paludinæ*, occurring in thin local bands in the Weald clay, and known as *Petworth, Bethersden*, and *Sussex marble.*

The beds immediately below the Purbeck series are termed the *Portland beds,* since they are typically developed in the peninsula near Weymouth, known as the Isle of Portland. These strata yield some of the finest freestone in the country. The highest bed, under the Purbeck "skull cap," yields the stone called *Roach;* this is a tough strong stone usually presenting a cavernous structure, due to the removal of fossils which it once contained, some of the commonest of these organic relics being the quarrymen's "screw-stones," or casts of *Cerithium Portlandicum.* Under the roach is the *Whit bed,* 8 or 10 feet in thickness, furnishing some of the best stone in the series; and at a yet lower horizon is the *Base bed,* which, though less durable, is also valued as a freestone, being indeed sometimes known as the "best bed." A rough inferior stone called *bastard roach,* and certain cherty limestones likewise occur in the Portland quarries. It should be mentioned that Portland stone is quarried, not only in Portland, but in the Isle of Purbeck, while varieties are also obtained in the Vale of Wardour and at Swindon. A large Ammonite (*A. giganteus*) characteristic of the Portland beds will be found at the base of the cast of the Dying Gladiator, on the opposite side of the Hall (No. 106).

Previously to 1623 Portland stone does not appear to have attracted much attention. From 1660 it has gradually grown into use. Inigo Jones restored a portion of Old St. Paul's, "casing great part of the outside, and adding a grand Corinthian portico to the west front, all of Portland stone." St. Paul's Cathedral and many of the city churches and other large buildings erected in the reign of Queen Anne, were constructed with stone very superior to that now generally employed as far as regards durability. The quarries from which Sir Christopher Wren obtained the Portland stone which he employed have been long deserted, the reason assigned being that the stone is a little harder, and thereby more expensive to work.

The Portland stone belongs to the Upper series of the *Oolitic* strata, or those which lie between the Cretaceous formation above and the Lias below. The name "oolite" (Greek, *oon*, an egg, *lithos*, a stone), is derived from the limestones of this group being, for the most part, made up of egg or roe-shaped particles, which are spheroidal concretions of carbonate of lime, each grain usually presenting a concentric structure, and enclosing a particle of sand, or some other substance, often organic, which has served as a nucleus. The Portland limestone is in parts distinctly oolitic, but it should be remembered that all the limestones belonging to the oolitic series do not present this peculiar texture, nor, on the contrary, is such oolitic structure confined

to rocks of this formation, some of the palæozoic limestones in certain districts, as near Bristol, being lithologically true oolites.

The famous *Bath stone* is a limestone of well-marked oolitic structure, occurring in that part of the lower oolitic series distinguished as the Great Oolite.

Bath stone possesses an agreeable warm tint, is worked with great ease, and may be obtained in blocks of large size, but some of it certainly does not possess great durability when exposed to the atmosphere of large towns. Certain varieties, however, such as that known as "Box Ground," have acquired reputation as weather stones which have stood admirably in Malmesbury Abbey and other ancient buildings. Bath stone is extensively employed, by reason of its softness when fresh-quarried, for ornamental mouldings and sculptured decorations. One peculiarity connected with this and other free-working limestones is that they become harder on their surfaces by exposure to the weather. This is said to arise not only from evaporation of the "quarry water," but from a slight decomposition taking place, which removes most of the softer particles, and leaves the hardest and most durable to act as a protection to the remainder.

The principal quarries, or in most cases underground workings, of this stone are those of Box, Combe Down, Monk's Park, Farleigh, Stoke, Westwood, and Corsham Down. In the restoration of Henry the Seventh's Chapel, the Combe Down stone was employed, costing about 40,000*l*.

A process has recently been used for increasing the durability of Bath stone, and similar stones, by treating the surface with a solution of some fluosilicate.

The *Inferior Oolite*, so called in reference to its position at the base of the Oolitic series, yields some famous freestones, of which numerous specimens are here exhibited. The Lincolnshire Limestone, belonging to the Inferior Oolite, is quarried in many localities in the Midlands, as at Ancaster, near Grantham, and at Weldon in Northamptonshire. Ancaster stone was used in Lincoln Cathedral; Ketton stone in parts of Ely and Peterborough Cathedrals; and Barnack stone was a favourite material with ecclesiastical architects as far back as the seventh century. In the West of England the Inferior Oolite yields excellent building stones, especially in the Cotteswold Hills; examples of which are shown from Painswick, in Gloucestershire, and other localities. The Doulting stone, from near Shepton Mallett, was used in parts of Wells Cathedral and Glastonbury Abbey. Ham Hill, in Somersetshire, yields a false-bedded, shelly limestone, of warm brown colour, reputed to be very durable, and recently used in several large buildings in London.

Immediately beneath the Oolites comes the broad band of the *Lias* formation—the term being probably a corruption from *layers*, as indicating the mode of occurrence of some of

its beds. The Lias extends across England, stretching in a north-easterly direction from near Lyme Regis, on the Dorsetshire coast, to Redcar on the coast of Yorkshire. The limestones of the Lower Lias, which are often of a blue tint, are usually more or less argillaceous, and form, when burnt, a valuable hydraulic cement; whilst the finer stones are used locally as building materials, and also as paving slabs: examples of lias limestones are shown from various localities in Dorsetshire, Somersetshire, and Warwickshire. The Sutton stone, from near Bridgend, in Glamorganshire, though at one time regarded as part of the "White Lias," or Rhætic series, is really referable to the Lower Lias.

It may be remarked that it is the practice of geologists to unite the Liassic with the overlying Oolitic formations under the general name of the *Jurassic* series—a name referring to the typical development of rocks of equivalent age in the Jura.

Most of the Permian limestones being magnesian are described below, under the head of "Dolomites;" whilst the majority of the other palæozoic limestones have already received notice under the head of "Marbles" (p. 22): a few cubes, however, being unpolished, find a place among the building stones. The Hopton Wood stone, from the Carboniferous limestone of Derbyshire, has been employed in the Imperial Institute; whilst Devonian Limestone, from near Babbacombe and Torquay, has been used in the New Record Office in Chancery Lane.

DOLOMITES OR MAGNESIAN LIMESTONES.—*Cubes in Wall Case IV. Antinous as Bacchus, No.* 59. *The Giustiniani Minerva, No.* 126.

The Dolomites—so called because they were first examined by a French geologist, Dolomieu,—are essentially limestones in which the carbonate of lime is replaced to a greater or less extent by carbonate of magnesia. These magnesian limestones are largely developed in the Upper Permian beds of the north-east of England, where they often exhibit peculiar concretionary structures, of which examples will be found in the collection of rock specimens in the Upper Gallery: the concretions, however, usually contain but little magnesia. As building materials the magnesian limestones are highly important, well selected varieties being exceedingly durable, especially when presenting a crystalline texture, and containing the carbonates of lime and magnesia in nearly equivalent proportions.

Dolomite is the stone which was selected, on the evidence of its durability at Southwell Minster, and in many other ancient structures, by the Commissioners for selecting the material for the Houses of Parliament. It is also the stone employed in the construction of this Museum. Experience has shown, however, that although some varieties are highly satisfactory, others are not well adapted for exposure to the atmosphere of London.

The more important quarries from which magnesian limestone is obtained in this country are those of Anston, of Brodsworth, Cadeby, and Park Nook, near Doncaster, of Huddlestone near Sherburne, and of Smawse near Tadcaster, in Yorkshire; while in Derbyshire the same stone of fine quality is obtained at Bolsover near Chesterfield, and in Nottinghamshire at Mansfield Woodhouse.

In some of the chemical works on the Tyne the dolomites of the northern counties are used for the production of carbonate of magnesia; while the magnesian limestones of Marsden have been taken in considerable quantities to Sunderland for the preparation of Epsom salt (*sulphate of magnesia*). Magnesian limestone is now largely used in the manufacture of basic bricks and lining of converters for the Thomas-Gilchrist process (p. 100).

SANDSTONES.—*Cubes in Wall Cases IV., V., and VI.*

A sandstone consists essentially of small grains of sand, mostly siliceous, cemented together into a solid rock. In some stones the grains cohere without any appreciable cement, but usually some kind of uniting medium is present. The nature of this cementing material is important, inasmuch as it determines to a large extent the durability of the stone; those varieties being most durable in which the cement is siliceous, whilst those in which the agglutinating medium is calcareous or argillaceous, are generally lacking in durability. In many sandstones the grains of silica are accompanied by small fragments of other minerals, such as felspar and mica, thus giving rise to varieties known as *felspathic sandstone, micaceous sandstone*, &c.

The formation of sandstone generally is instructively illustrated by a specimen of recently-consolidated sand from Newquay, in Cornwall, and many similar examples exist around our western coasts, where hills of blown sand prevail. The water percolating through the upper layers dissolves the carbonates of lime and of iron, which are re-deposited as cementing materials, on the evaporation of the water as it filters through the lower strata of the porous sand.

In texture and colour sandstones are subject to considerable variation, according to the size of the grains and the nature of the cement. The red, brown, and yellow colours exhibited by many sandstones are due to the presence of peroxide of iron, either in an anhydrous or in a hydrated condition; this material being usually present as a pellicle investing the sand-grains, or as a cement. Many sandstones and other rocks, though of brown or yellow colour on exposure to the oxidising influence of the atmosphere, are "blue hearted," or of a cold bluish tint when fresh-quarried: the blue tints may be due to the presence of ferrous carbonate, or of finely-divided iron-pyrites, or even of phosphate of iron.

Although sandstones are highly valued as durable building materials, their use in London is far less extensive than that of

limestones, partly because they are not so readily worked, and partly because good sandstones are not common in the south-east of England. The sandstones of the Tertiary and upper Secondary formations, are in fact generally too soft. The "grey wether sandstone," however, is a material of exceptional durability, as attested by Stonehenge and other megalithic monuments in which it has been used; yet this is merely an altered sandstone from certain Eocene deposits which were once spread over the chalk downs.

The "hearth-stone" and "fire-stone," of Surrey, are soft calcareous sandstones from the Upper Greensand, at the foot of the chalk escarpment. At Godstone the stone is worked in subterranean galleries, which are really mines. The Lower Greensand yields in many localities brown sandstones and grits, called "carstone," employed locally for building. Several sandstones from the Trias are exhibited; whilst many of these are red stones, others are white and even greenish, as shown by the Quarella stone, quarried near Bridgend, in Glamorganshire. The red and white Mansfield stones are dolomitic sandstones, associated with the magnesian limestone of the Permian series.

The Carboniferous system is rich in excellent sandstones, especially in Yorkshire, Lancashire, and Derbyshire, where they are worked both in the coal-measures, and in the underlying millstone-grit; examples are exhibited from Bramley Fall, near Leeds; from Darley Dale, in Derbyshire, and many other well-known localities.

A *Grit* is a rather coarse sandstone, containing sharp angular grains. The Millstone Grit is in some parts a *conglomerate*, with rather large pebbles of quartz; whilst in other cases it becomes felspathic, and has evidently been derived from the disintegration of granite; such a rock is sometimes termed *arkose.*

In the Midland Valley of Scotland, the Lower Carboniferous series includes many valuable sandstones, such as those of Craigleith, so largely employed in Edinburgh. These sandstones occur in the upper part of the Calciferous Sandstone series known as the "Cement stone group." The term "liver rock," is applied to the thick-bedded sandstones, which can be quarried in large blocks.

The collection of sandstones includes, in addition to the specimens already referred to, several cubes from the Old Red Sandstone, a formation which yields, especially in certain parts of Scotland, much useful stone not only for building but for paving purposes.

Flagstones and Tilestones.—*Wall Cases IX. and X.*

Two small Cases have recently been erected against the wall opposite to the general collection of building-stones, for the display

of specimens of rocks which are capable of being split, along the planes of bedding, into slabs suitable for use as flagstones, &c. The streets of London are partly paved with *Yorkshire flagstones*, which are pale brown micaceous sandstones from the Lower Coal Measures of the Yorkshire coal-field. The *Caithness flagstones* are dark-grey bituminous and calcareous sandstones, from the Lower Old Red Sandstone; whilst the *Arbroath flagstones*, from Forfarshire, are obtained from the same formation.

With the arenaceous flagstones are placed certain fissile limestones, which being easily split into thin slabs, are used locally for roofing, under the name of "slates." These tiles were largely employed by Gothic architects, and are still used in ecclesiastical architecture, though generally superseded for domestic purposes by the highly cleavable and lighter Welsh slates. The principal fissile limestones are the *Stonesfield slate*, which occurs at the base of the Great Oolite in Oxfordshire, and the *Collyweston slates* which are found immediately below the Lincolnshire Limestone, in the lower part of the Inferior Oolite near Stamford. The *Duston slates* have been obtained from the Inferior Oolite (Northampton Sands). Thin slabs of Forest Marble, for roofing, are got at Poulton, near Fairford, and other places. It is worth noting that many of these stones, after being quarried, are exposed to the disintegrating action of the winter's frost, whereby their fissile structure is developed, and they are then easily split up.

Slate.

This valuable material is a highly indurated argillaceous rock, readily cleaved in certain directions into thin laminæ or plates; and upon this fissile structure depends to a great extent its economic value. Most slate contains much finely-divided mica of secondary origin.

The beds, deposited originally as a fine muddy sediment, appear to have been subjected, long after consolidation, to the action of intense lateral pressure; the effect of which was not only to contort the beds, but also to induce a re-arrangement of the particles of the rock, the flattened sides of these particles being forced by the lateral compression into positions transverse or at right angles to the direction of the pressure, and hence the rock readily cleaves parallel to that direction in which all the particles are thus definitely arranged. All contorted strata are not, however, cleavable. Experiments on cleavage have shown that a similiar, though much less perfect, fissility may be artificially developed by simple mechanical compression; the direction of the induced cleavage being always perpendicular to that of the applied pressure.

In some cases the direction of the original bedding may be seen on the cleaved surface in the form of bands, known to quarrymen as the *stripe* of the slate.

A collection of slates, admirably illustrating the cleavage of the rock, is arranged against the wall under the west window at

the south end of the Hall, overlooking Jermyn Street. Most of these specimens are from North Wales.

The slate quarries and mines of North Wales are celebrated for the excellent character of the slates which they produce. The most celebrated quarries are those of Penrhyn and Llanberis, which are worked in the Lower Cambrian series of Carnarvonshire. Other Welsh slates, of less importance, are obtained from higher horizons in the Cambrian systems. The slates of the Ffestiniog and Corris districts are worked in Lower Silurian strata; whilst those of Llangollen are in Wenlock beds, of Upper Silurian age.

The "green slates" of the Borrowdale series of the Lake district are finely-divided volcanic ashes, more or less cleaved by pressure. Slate pencils have been largely made from some of the Skiddaw slates.

The Devonian rocks of the north-eastern part of Cornwall, and of neighbouring districts in Devonshire, yield slates, more or less valuable for roofing purposes. The Delabole slate quarries, situated near Tintagel, in Cornwall, have been long celebrated for producing a durable material combining considerable lightness with strength. In 1602 Carew, in his *Survey of Cornwall,* speaks of *healing stones* (in many districts roofing slates are still called *hailings* or *healings*, probably from *hele* or *hail,* to hide, and hence the name of *helier* given to a tiler or slater):—"in substance thinne, in colour faire, in waight light, in lasting long, and generally carrieth so good regards as (besides the supply for home provision) great store is yearly conveyed by shipping both to other parts of the realme, and also beyond the seas, into Britaine and Netherland." Borlase, in 1758, speaks of the extent of the workings of Delabole. The Delabole quarries, now merged in one huge pit, produce not only roofing slates, but flagstones which are employed for pavements in passages, courts, yards, &c. and for tombstones. The inscriptions upon old tombstones of the Delabole slate remain remarkably perfect, showing its durability when exposed to atmospheric influences.

Slates are subject to considerable variation both in colour and texture. Good roofing slate should be hard, tough, and fine-grained, emitting a metallic ring when struck; it should absorb but little water, and be so compact as not to be decomposed by the action of the atmosphere. Iron-pyrites, which is by no means uncommon in many slates, is apt in some cases to decompose and disfigure the slate with rusty blotches; but certain kinds of pyrites are capable of resisting, to a remarkable extent, the action even of a town atmosphere.

Slabs of slate which are not fit for splitting into roofing slates are cut with a circular saw into pieces of from half an inch to two inches thick, and are used for flooring, landings, steps, cisterns, mantel-pieces, &c Slate slabs are also extensively enamelled, and employed for ornamental work in the place of marble.

Marble Table-Tops.—*Nos.* 115, 117.

On each side of the base of the large statue of Hercules is a table inlaid with a large display of marbles and other ornamental stones. These inlaid table-tops were obtained from the late Mrs. Bury Palliser, whose husband, Capt. Palliser, had purchased them from Prof. Corsi, of Rome, the eminent authority on ancient stones, and author of the treatise "Delle Pietre Antiche" and other works. Each table contains 1,012 specimens, in the form of square slabs, measuring about an inch and a quarter in the side. The stones in one of the tables (No. 117) are from ancient buildings in Italy, Greece, and Africa; those in the other table (No. 115) are from modern sources. Although it is not the purpose of this Museum to display foreign marbles, an exception has been made in favour of these tables, in consideration of the fact that the specimens were collected by Corsi and named on his authority. A Catalogue is in the custody of the Doorkeeper, for consultation by visitors.

Grinding and Polishing Stones.—*Table Case VIII.*

There are many mineral substances used for the purpose of giving fine edges to cutting instruments or a polish to metal and other surfaces; and the collection in this case, mostly presented by the late Mr. R. Knight, is intended to illustrate this class of materials. The series is in course of re-arrangement.

Newcastle grindstones, proverbially said to be found everywhere, are formed from sandstones which abound in the coal districts of Northumberland, Durham, Yorkshire, and Derbyshire.

At Bilston, in Staffordshire is found lying above the coal a peculiar sandstone, finer than the above, and of a very sharp nature. This is quarried entirely for the *Bilston grindstones*, which are of great excellence.

The *carpenter's millstone* is a hard and close variety of Yorkshire sandstone. The northern counties yield several varieties of grindstones, which are much in request for different descriptions of work: *Yorkshire grit*, for example, is used for polishing marble and the copper plates for engravers. The *Sheffield grindstone* is a hard and coarse stone used for common purposes; it is found at Hardsley, 14 miles north of Sheffield. The *Sheffield blue stone* is a fine-grained stone, used for finishing fine goods. The act of grinding on a blue stone is termed "*whittening*"—the Sheffield whittle from the earliest periods having been in all probability ground on this stone. *Wickersley stones* are obtained about nine miles from Sheffield, and are much used by the cutlers for grinding.

Devonshire bats are in much repute. These are porous fine-grained sandstones found in the quarries of the Black Down Hills, near Cullompton.

Hone Slates are slaty stones used in straight pieces for sharpening tools after they have been ground on revolving grindstones. The more important varieties are the following:—

The Norway ragstone, which is the coarsest variety of hone slate, is imported in large quantities from Norway. In Charnwood Forest, near Mount Sorrel, in Leicestershire, particularly from the Whittle Hill quarry, is obtained the *Charley Forest stone,* said to be one of the best substitutes for the Turkey oilstone, and it is much in request by joiners and others. *Ayr stone, snake stone,* and *Scotch stone* are used especially for polishing copper plates. The *Welsh oilstone* is almost in equal repute with the Charley Forest stone; it is obtained from the vicinity of Llyn Idwal, near Snowdon, and hence it is sometimes called *Idwal stone.* From Snowdon is also obtained the *cutler's green stone.* The *Devonshire oilstones,* obtained near Tavistock, which were introduced by Mr. John Taylor, are of excellent quality, but the supply being irregular, they have fallen into disuse.

The German razor hone, which has been long celebrated, is obtained from the neighbourhood of Ratisbon, where it occurs as a vein running through blue slate, varying in thickness from one to eighteen inches. When quarried it is sawn into thin slabs, and these are generally cemented to slices of slate which serve as a support. The *Washita* and *Arkansas* oil-stones are made from the fine siliceous rock called *novaculite.*

The *Turkey oilstone* is said to surpass in its way every other known substance, and it possesses in an eminent degree the property of abrading the hardest steel: it is, at the same time, of so compact and close a nature as to resist the pressure necessary for sharpening a graver, or any instrument of that description. There are black and white varieties of the Turkey oilstone, the black being the harder, and it is imported in somewhat larger pieces than the white; they are found in the interior of Asia Minor, and brought down to Smyrna for sale.

Among the examples of mineral substances employed as burnishers and here exhibited, will be found a specimen of *agate* (p. 54), and a piece of *hœmatite* or *red iron ore* (p. 75).

The *corundum* and *emery* exhibited in this case are varieties of *alumina,* a mineral which is presented in its purest form in the ruby and sapphire. Emery is obtained from the N.E. part of the island of Naxos, and from near Ephesus in Asia Minor; it occurs also in many localities in the United States. From its excessive hardness it is used as an abrasive agent; and is also employed for polishing, for which purpose it is prepared by grinding and washing, and the finest is sold under the name of *flour of emery.* Emery is largely used in the arts, principally in the convenient form of emery-wheels, emery-cloth, &c,

In addition to the stones which have been already mentioned, there will be found in this case a series from France showing the celebrated "*Burr Stones*" of La Ferté-sous-Jouarre (Seine et Marne). The combined roughness and hardness of this tertiary

siliceous rock give it immense advantages, expensive though those stones are, in consequence of the necessity of carefully piecing them together.

Some of the lavas from the extinct volcanoes of the Lower Eifel furnish millstones which have long been justly celebrated. They were well known to the Romans, and are still extensively quarried at Niedermendig, near Andernach, whence they are sent down the Rhine to Holland, and exported to most parts of the globe. Under the name of " Dutch Blue Stones " they were formerly much used in this country.

Plaster of Paris. Cements.—*Cases V., VI., VII. Cast of Apollo Belvedere,* 159; *of Dying Gladiator,* 86; *of Greek Vase,* 104. *Pavement in Keene's Cement,* 11.

The well-known mineral *Gypsum* is a hydrous sulphate of lime occurring abundantly in the New Red or Keuper Marls, often associated with rock salt. When transparent and crystallized, it is known as *selenite,* and, when fibrous, as *satin spar;* specimens of both varieties will be found in Case V. The fine semi-crystalline form of gypsum termed *Alabaster* has been already noticed as an ornamental stone (p. 28). All these substances are natural hydrates; but the mineral called *Anhydrite* is a sulphate of lime, destitute of any essential water, its composition being lime, 41·18; sulphuric acid, 51·82.

When gypsum is calcined at a moderate temperature, it parts with the whole of its water, and has then a composition resembling that of anhydrite. Calcined gypsum, when reduced to powder, forms the well-known *Plaster of Paris,* so called from the circumstance that the mineral from which the plaster is obtained is found in abundance in the tertiary deposits of the Paris basin, especially at Montmartre. Mixed with sufficient water to convert it into a paste, the plaster eagerly absorbs the liquid, and, returning to its original hydrated condition, rapidly solidifies or *sets.* If, however, the gypsum be overburnt this setting is prevented, and the material is as useless as powdered anhydrite would be. To ensure rapid consolidation it is desirable to so perform the calcination that about 5 per cent. of water is left in the plaster. Good plaster of Paris is far from being an anhydrous sulphate.

The facility with which, by means of plaster of Paris, copies of any objects can be obtained renders it of great value in multiplying the finest works of ancient and modern art. Some applications are shown in this case.

Fictile ivory, of which there are several examples, is plaster of Paris, which, after drying, has been made to absorb melted spermaceti; or it may be prepared according to Mr. Franchi's process as follows: Plaster and colouring matter are employed in the proportions of a pound of superfine plaster of Paris to half an ounce of Italian yellow ochre. They are intimately mixed by

passing them through a fine silk sieve, and a plaster cast is made in the usual way. It is first allowed to dry in the open air, and is then carefully heated in an oven; the plaster cast, when thoroughly dry, is soaked for a quarter of an hour in a bath containing equal parts of white wax, spermaceti, and stearine, heated just a little beyond the melting point. The cast on removal is set on edge, that the superfluous composition may drain off, and, before it cools, the surface is brushed with a brush like a sash tool, to remove any wax which may have settled in the crevices; and finally, when the plaster is quite cold, its surface is polished by rubbing it with cotton wool.

Some casts, as will be seen, are in very high relief; these are made in elastic moulds,—a composition of glue and treacle, which admits of being turned out from the "under-cutting" without injury.

By subjecting plaster of Paris to certain methods of chemical treatment, it may be hardened to a considerable extent, and thus becoming much less liable to injury, its value as a cement is greatly increased.

Keene's Cement, according to the specification, is thus prepared:—Dissolving one pound of alum in a gallon of water, this solution is used for soaking 84 pounds of gypsum calcined, in small lumps. These lumps are then exposed for eight days to the air, and afterwards calcined at a dull red heat and then ground and sifted.

The *Parian cement* is prepared by soaking the plaster in a solution of borax instead of one of alum. This is exemplified in the cast of the "Dying Gladiator" and its base (No. 86), as well as in the coloured cement on the stairs, in which Derbyshire marbles, to be found in the collection, are imitated, for the purpose of showing to what extent the realisation of a natural stone can be secured in an artificial material. *Martin's cement* is formed by combining pearl ash (bi-carbonate of potash) and alum with the plaster, hydrochloric acid being sometimes added to prevent an alkaline re-action.

Scagliola differs from all these cements, in consisting of small fragments of marble and other ornamental substances, embedded in a base formed of a mixture of plaster of Paris and glue. This was the invention of Guido del Conte, an ingenious mason of Cari, near Corregio, in Lombardy. Scagliola was much employed by the Florentines in some of their most elaborate works.

Roman cement was at one time largely made from the septaria or "turtle stones," which occur abundantly in many beds of clay. Quantities of these cement-stones were formerly procured by dredging off the coast of Hampshire, off the Isle of Sheppey, and at Harwich; the septaria being derived from the London clay. *A septarium* is simply a nodule of argillaceous limestone, often containing in its interior an organic substance serving as a nucleus around which the limestone aggregated.

The contraction suffered during desiccation has produced fissures or cracks, which have subsequently been filled by deposition of carbonate of lime. These veins of calcite being disposed with tolerable regularity through a darker base, produce on section a peculiar pattern which is well seen in the polished Slab No. 157.

Portland cement, which has practically superseded the use of Roman cement, is made by calcining a mixture of chalk and finely divided argillaceous matter, such as the mud dredged from the Thames and the Medway. It is also prepared from Lias limestone and the associated Lias shales; and from Carboniferous limestone mixed with local clays. A large series illustrating the cement industry is now in course of arrangement (1895).

With the cements will be found some specimens of *artificial stone,* prepared by Mr. Fred. Ransome, of Ipswich. This gentleman has at different times patented several processes for this purpose, but the general principle consists in using water-glass (silicate of soda) as a cement by which sand is formed into a compact stone, remarkable for its high cohesive power. By the side of this artificial stone are some specimens of flints which have been acted upon by heated soda, in the preparation of the sodium silicate. Ordinary flints are subjected to the action of a strong solution of caustic soda in digesters under steam pressure of from 60 to 80 lbs. to the square inch, and are rapidly dissolved with production of solution of silicate of soda. In 1870 Mr. Ransome effected a great improvement in the manufacture of his artificial stone by mixing the Farnham stone, or soluble silica, with silicate of soda or of potash, lime, sand, alumina, chalk, or other convenient materials; the alkaline silicate is then decomposed, the silica combining with the lime to form an insoluble silicate of lime, and also forming with some of the materials a silicate of alumina, whilst the caustic alkali set free by the decompostion seizes upon the soluble silica of the Farnham stone and forms a fresh silicate, which in turn is decomposed by more lime. This material called *Apœnite,* is exhibited in this Case, and its application is further illustrated by the Vase No. 105.

BASALT.—COLUMNS FROM THE GIANTS' CAUSEWAY. *No.* 90.

These specimens well illustrate the peculiar columnar structure which basalt very frequently assumes, and on which depends the characteristic scenery of the Giants' Causeway, the Isle of Staffa, and other well-known basaltic districts. The basalt of which these are composed is a dark-coloured, fine-grained, igneous rock, composed of an intimate mixture of felspar, usually labradorite, and augite, associated with olivine, magnetic iron, &c. The columns, as seen by the specimens exhibited, are large polygonal pillars, often six sided, each prism being usually terminated by a convex face at one end, and a corresponding convexity at the other; and by a kind of ball-and-socket joint thus formed, the individual columns are articulated one to another.

Large Mass of Native Copper from the Mine at the Ghostcroft, Mullion, Cornwall. *No.* 99.

Trenance mine, from which this remarkable specimen was obtained, was worked near Mullion, close upon the junction of the serpentine with the hornblende-schist. It is not unusual to find, in the fissures of the serpentine rocks, masses of native copper; these have frequently induced a further search for mineral treasure, which has rarely been successful. The specimen, which was presented by the adventurers, is only a portion of the mass as it occurred in nature; the miners being compelled to break it in order to raise it to the surface.

Part of a Lead Vein or Lode from the Grassington Mines. *No.* 95.

The Grassington mines, the property of the Duke of Devonshire, by whom this fine specimen was presented, were at one time the most important in Yorkshire. This example shows in a very instructive manner the mode in which, ordinarily, lead ore occurs in nature. By looking at the transverse section, which hangs upon the east wall of the Model Room (A.), it will be seen that the strata in which this lode occurs have been dislocated—with formation of a fissure running almost vertically through all the beds. In this crack the mineral deposit has taken place; the mineral here formed being the sulphide of lead, or galena (p. 74) associated with sulphate of barium (p. 108).

Copper Ore from South Australia. *No.* 89.

This large specimen exhibits a superficial coat of *malachite*, or green carbonate of copper, encrusting a fine mass of *cuprite*, or red oxide of copper. These minerals are frequently present in the upper part of deposits of copper ore, where atmospheric action has penetrated. The specimen before us was obtained from the shallow workings of the Great Northern Copper Mining Company of South Australia. (*See also* p. 89.)

Apatite from Canada. *No.* 87.

Some of the most ancient rocks known to the geologist occur in the dominion of Canada, and from their development in the Laurentide Hills, north of the River St. Lawrence, have received the name of the *Laurentian series*. This system of rocks contains thick beds of crystalline limestone, and in this limestone the mineral called *apatite* occurs. Apatite is a phosphate of lime, associated with more or less chloride of calcium. The Canadian mineral frequently presents a sea-green colour and a crystalline texture, as seen in the block before us, which was presented by

Messrs. Pickford, Winkfield, and Co. This specimen exhibits the apatite in association with a variety of mica known as phlogopite. The Canadian apatite is most abundant in the townships of Burgess and Elmsley; the present specimen was obtained from North Burgess Mine, Perth. The mineral has economic value, since, by treatment with sulphuric acid, it is converted into a soluble superphosphate, which is highly prized by the agriculturist as a fertilizing agent (p. 110).

By the side of the Canadian phosphate is a fine sample of *phosphorite*, or impure phosphate of lime, from Staffel near Limburg, on the Lahn.

Portion of a Vein of Gold-bearing Quartz. *No.* 162.

The discovery of gold in California, in June 1848, produced an extraordinary amount of excitement in this country and in the United States. The gold from the deposits in the beds of the tributaries running into the Sacramento, and in the alluvial valleys of the country, becoming, from the eager search which was made for it, unequal to the desires of the adventurers, the quartz-lodes, which were discovered in the rocks, became the objects of exploration. Numerous mines were opened, and workings commenced upon these quartz-veins on an extended scale. The specimen exhibited is from the Grass valley, Nevada county, and was presented by the late Mr. F. Catherwood; it fairly represents all the average conditions of the gold-bearing quartz-lodes, not only of California, but of Australia and other countries. Small particles of gold are here and there visible, and gold is disseminated through the mass, but so finely divided as to be invisible. Some very rich fragments of gold-quartz are in the same Case.

An exceptionally fine specimen of crystallised *Quartz* (No. 134), from Weardale, in Durham, is mounted on a Pedestal in the north-west corner of the Hall, close to the entrance to the passage, covered by a red curtain, leading to the Offices. In the opposite, or north-east, corner is a very fine block of *Cannel* (No. 53), from near Wigan, in Lancashire, and a few *fossil tree-trunks* from the Coal Measures. (Nos. 52, 54, 55.) With these are placed some examples of *silicified wood*, from the 'Dirt-bed' of the Purbeck series in the Isle of Portland (No. 56), and from the so-called fossil forest near Cairo in Egypt. (No. 100).

THE PRINCIPAL FLOOR

Two flights of steps, in Portland stone, lead from the Hall to a landing, on which are placed three cabinets containing part of the Ludlam Collection of Minerals. From this landing a stone staircase, with ornamental metal castings on each side, conducts the visitor to the Principal Floor of the Museum. At the head of the staircase, on the right hand, is a large iron casting of *Venus* (No. 48), while a corresponding casting of *Diana* (No. 47) stands on the left side. Close to these figures are two small Table Cases (Nos. 46 and 49) for the exhibition of recent acquisitions to the Mineral collection.

The Principal Floor of the Museum contains the Mineralogical, the Metallurgical, and the Ceramic series, associated, however, with various miscellaneous objects. The *mineralogical* series is separable into two divisions: the *metalliferous*, containing the ores of our ordinary metals; and the *non-metalliferous*, or those minerals which are either entirely destitute of metal or, at most, contain only some of the lighter and rarer metals. The metallic minerals are arranged in the 56 Wall Cases around this floor of the Museum (p. 66), whilst the non-metallic minerals are displayed in the large central case which is known, from its original shape, as the Horseshoe Case (p. 101). This Horseshoe Case surrounds the glass roof of the lecture theatre below, and forms a prominent object in the centre of the room. The *metallurgical* series is arranged in the six Flat Cases in the embayments in front of the British metallic minerals (p. 92), but the space thus allowed being insufficient, the metallurgical specimens have crept into several of the adjacent Pedestal Cases in the central area.

The original intention of those who devised the arrangement —an intention which has been carried out wherever practicable —was to exhibit the ore or raw material in the wall-cases; then to show the treatment to which the ore was subjected, for extraction of metal, in the Flat Cases immediately in front of the ores; whilst the applications of the metals in the arts would be illustrated by specimens in the Pedestal Cases in front of the metallurgical collection. Thus the ores of copper are exhibited in Wall Cases **1, 2, 3, 4,** &c.; the metallurgy of copper is represented in the Flat Case No. 40, in front of these Wall Cases; and finally the casting of copper and its alloys is illustrated by statuettes in the Pedestal Case No. 42, which, again, is immediately in front of No. 40.

The *ceramic* and *vitreous* series is separated as far as possible from the other collections on this floor, and forms a compact group of objects at the southern end of the room (p. 120). In addition, however, to these systematic collections there are exhibited in this gallery a large number of models and miscellaneous objects; and as some of these are likely to arrest the attention of the visitor as soon as he reaches this floor by the stairs leading from the Hall, it may be desirable to commence

our survey by describing the objects which will be found in the central area.

The most striking object seen on entering this part of the Museum is the large Siberian vase (No. 1) which stands immediately in front of the staircase.

CENTRAL CASES AND MODELS.

VASE OF SIBERIAN AVENTURINE.—*Bequeathed by Sir R. I. Murchison, Bart., K.C.B., F.R.S. No.* 1.

This handsome vase was presented in 1843 by the Emperor of Russia, Nicholas I., to Sir R. I. Murchison in recognition of his services in exploring the geology of part of the Russian Empire. The material of the vase is a micaceous quartz-rock, passing into aventurine (p. 112). The flakes of mica are arranged in irregular bands running obliquely across the oviform body of the vase, whilst the whitish colour of the stone is relieved by iron-stained patches, of brown and yellow tints. A mottled pink variety of quartz-rock forms the base of the vase, which is distinct from the body; and the whole is supported on a handsome pedestal of grey porphyritic rock. The materials of both vase and pedestal were obtained from the hills of Bieloretsk and Korgon, a dependence of the Altai Mountains, and were polished in the Government of Tomsk. The vase is four feet in height, and measures six feet in circumference at its largest part.

RUSSIAN STEEL WORK, &c.—*Bequeathed by Sir R. I. Murchison, Bart., K.C.B., F.R.S. No.* 2.

A small Table Case, standing immediately behind the Siberian vase, contains some interesting objects bequeathed to the Museum by Sir R. Murchison. One of these is an ornamental steel plateau, or salver, manufactured at Zlataust, in the Ural Mountains. This town, which has been called "the Birmingham and Sheffield of the Ural," is situated on the banks of the River Ai, in a romantic valley on the western side of the watershed of the Ural. A view of the locality adorns the centre of the plateau. Under General Anosoff, the Imperial Steel Works of Zlataust attained great celebrity for the manufacture of sword blades.

The plateau is ornamented with a border representing allegorically the manufacture of a sword, and some examples of the actual swords will be found in Pedestal Case No. 13. The plateau is formed in burnished steel richly ornamented with damascene work, and bears an inscription in Russ, which has been thus translated:—

"To the geologist R. Murchison, in testimony of its particular esteem, the Administration of Mines in Russia, Zlataust, 1843."

Another prominent object in this case is a gold snuff-box, set with a large number of diamonds, and ornamented with an enamel portrait of the Emperor of Russia, Alexander II. This box was presented to Sir R. I. Murchison by the Emperor Nicholas.

Geological Model of London. *No.* 3.

This large Model was constructed by the late Mr. T. B. Jordan, under the superintendence of Mr. W. Whitaker, of the Geological Survey. It represents a tract of country around the metropolis as a centre, measuring about 15 miles from east to west, and about 11 miles from north to south; or a total area of something like 165 square miles. The horizontal scale is the same as that of the county maps of the Ordnance Survey, namely, six inches to the mile; whilst the vertical scale is 200 feet to the inch, or about 4·4 times as great as the former. Had the vertical scale been the same as the horizontal, as was originally intended, the heights on tae model would have been so insignificant, that the highest point which it includes, the top of Hampstead Heath, would have been represented by a rise of little more than half an inch. An exaggerated vertical scale was therefore absolutely necessary in order to exhibit with due effect the undulations of the ground. It will be observed that although the area around the metropolis is popularly known as the "London Basin," this basin is in fact nothing more than an extremely shallow depression; and even with the exaggerated dip represented in the model, the beds slope towards the centre of the trough at a very slight inclination.

The oldest rock which comes to the surface within the area of the model is the chalk: but several deep wells sunk in the London basin have reached the underlying rocks. The beds below the chalk are seen in section on the sides of the model. In fact the model is constructed in nine separate blocks, five of which can be raised by means of a winch so as to expose the sections on their inner sides.*

By far the greater part of the country represented in this model is formed of strata overlying the chalk and belonging to the tertiary series. These consist of the Thanet beds, immediately above the chalk; followed by the Woolwich-and-Reading series, the Oldhaven beds, and the London Clay. This clay, which may reach a thickness of about 400 feet under the Metropolis, is covered on the hills of Hampstead and Highgate by sandy beds known as the Lower Bagshot Sands. The post-tertiary gravels, sands, clays, brickearth, &c., spread more or less extensively over the older strata, are grouped together under the general

* Visitors desirous of inspecting the sections on the sides of the movable blocks, should apply to the officers of the Museum for permission to raise them, but should not otherwise attempt to disturb the model. The geological maps under the gallery should be drawn up and down by the policeman on duty, and not by the visitor.

name of Drift. A system of colouring exhibits the distribution of the several formations, including these superficial deposits; but by exposure to the light, some of the colours have faded. A map on the same scale is, however, mounted on rollers under the neighbouring gallery, and the colours are here well preserved. For further information the visitor should consult the *Guide to the Geology of London* (price, 1s.), written by Mr. Whitaker in explanation of this Model and of the Geological Survey Map of London and its Environs.

MODEL OF THE CHAIN OF PUYS, AUVERGNE.—*Presented by the late G. Poulett Scrope, M.P., F.R.S., &c. No.* 43.

Little more than a century ago two French travellers returning from Italy observed that the rocks in certain parts of their route through Central France bore a striking resemblance to the volcanic products of Vesuvius. Although at first received with considerable opposition, the truth at length became established, that at a comparatively recent geological period the interior of France had been the theatre of energetic and frequently-repeated volcanic action. One of the most interesting groups of these extinct volcanoes is represented in the model before us, which is placed opposite to the model of London, one being on each side of the Central Vase.

The volcanic hills of the department of the Puy-de-Dôme form an irregular chain, running nearly north and south, and rising from the granite plateau which forms so prominent a feature in the geology of Auvergne. The surface of this granite presents several depressions, formerly occupied by lakes, the existence of which is now marked by certain fresh-water deposits, of which the largest forms the fertile plain of the Limagne, represented on the eastern side of the model. Passing westward from the valley of the Allier, we cross the calcareous marls and other lacustrine deposits on the margin of the Limagne, and reach the eastern escarpment of the granitic table-land which, extending in width for about 12 miles, slopes on the western side to the valley of the Sioule. The chain of "puys," which rises from this platform, includes about 70 volcanic hills, of which the largest is the Puy-de-Dôme, a mountain rising 4,844 feet above the sea-level. Most of these hills are composed essentially of the scoriæ, lava, and other volcanic products, which, accumulating around the orifices of eruption, have formed conical hills, often presenting at the summits well-defined craters, from which, in many cases, distinct streams of lava may be traced. The Puy-de-Dôme and a few other hills consist of a peculiar trachytic rock called, from this locality, *domite*.

In the drawers beneath the model is an interesting group of rock specimens illustrating the geology of the district, presented mostly by Prof. C. Le Neve Foster, F.R.S.

Specular Iron Ore, *No.* 44; Agate, *No.* 5.

On a pedestal close to the model of the Auvergne volcanoes is a magnificent specimen of specular iron-ore on lava, from the Island of Ascension. The formation of specular iron-ore in volcanoes probably results from the action of watery vapour on perchloride of iron; hydrochloric acid being set free, whilst peroxide of iron is deposited in a crystalline form.

On the opposite side of the museum, close to the model of London, is an exceptionally fine polished specimen of South American Agate, on the pedestal No. 5. Nearly all the agates which are brought into commerce are obtained from Uruguay, in South America, whence they are exported to Germany, and are cut and polished in the neighbourhood of Oberstein, on the River Nahe, a tributary to the Rhine. (*See* p. 54.)

Cores from Deep Borings. *Case No.* 41.

A very interesting series of specimens showing the strata passed through in various deep borings, chiefly in the neighbourhood of London, is arranged in this case.

In the years 1855, a boring for water, known as the Kentish Town boring, undertaken by the Hampstead Water Works Company, at a spot situated at the foot of Highgate Hill, passed through the Chalk, the Upper Greensand and the Gault, and then, at a depth of about 1,114 feet, entered red rocks of doubtful age, specimens of which are here exhibited. Soon afterwards a boring at Harwich showed that the Gault was there immediately followed by a dark slaty rock, apparently of Lower Carboniferous age. A suite of specimens from the Harwich boring is in this case.

From these two borings it was discovered, for the first time, that in certain parts of the East of England, the strata below the Gault did not follow in their normal sequence, and that rocks of Palæozoic age might, by the absence of many members of the Secondary series, be brought up within a moderate distance of the surface. No further evidence respecting these underground old rocks was, however, obtained until the year 1877, when a boring at Meux's Brewery in Tottenham Court Road, showed that Upper Devonian rocks, fossiliferous and highly inclined, were present at a depth of only about 1,066 feet. In addition to the specimens in this case, others will be found mounted on the pedestal No. 16. Shortly afterwards the New River Company struck fossiliferous Devonian shales at 980 feet in a boring at Turnford, near Cheshunt; whilst at Ware, in Herts, Wenlock beds (Upper Silurian) with characteristic fossils, were obtained from a depth of less than 800 feet. Some remarkably fine cores from these two borings are exhibited at the foot of the Staircase, on each side leading to the Gallery.

Within the last few years deep borings have multiplied, and samples of cores from many localities are collected in this Case

(No. 41). Red rocks of uncertain geological position have been found south of the Thames, at Crossness, at Streatham, and at Richmond. The deep boring at the Richmond water-works, described by Prof. Judd, passed, after piercing the Gault, through a small thickness of what are believed to be Neocomian beds, followed by about 87 feet of strata representing the Great Oolite, and then entered red sandstones and marls, similar to those so often found within the London area.

Although specimens of the underground floor of ancient rocks beneath the London Basin are those of most interest, there are other samples in this case showing cores from deep borings elsewhere, as at Stutton, near Ipswich; at Swindon, and in Northamptonshire and Cheshire.

Illustrations of the Sub-Wealden Exploration.
Case No. 19.

On the occasion of the meeting of the British Association at Brighton in 1872, a bold geological experiment was projected by Mr. Henry Willett. The experiment consisted in an attempt to ascertain the thickness and order of succession of the several secondary rocks beneath the Wealden area in Sussex. For some years the notion had been gaining ground among geologists that these secondary rocks were comparatively thin in the south-east of England, and that some of them might be altogether absent, so that the older or palæozoic rocks would probably be found within a moderate depth. The site finally selected for the enterprise was in the parish of Netherfield near Battle. After the boring had reached a depth of 1,030 feet an accident led to the abandonment of this hole, and a new boring was commenced with diamond-mounted drills on an adjacent spot. The second boring attained a depth of nearly 2,000 feet, when it was found necessary to suspend the work for lack of funds.

The Case before us contains a geological model of the Wealden area, by the late Mr. W. Topley and Mr. J. B. Jordan. There are also a number of solid cores of rock drilled out by the boring tools: some of these were extracted by the old-fashioned tools employed at the commencement of the work, but most of them were obtained by the diamond-mounted drills. Some of these steel crowns, set with rough black diamond or carbonado (p. 103), are here exhibited; whilst the machinery employed at the surface is represented in the accompanying photographs. The borings were commenced in the Purbeck series, and valuable gypsum (p. 109) was discovered at a moderate depth; this mineral is now worked commercially at Netherfield. A great thickness of Kimeridge clay was penetrated, much of which was found to be highly fossiliferous, and below the Kimeridge clay the borers reached beds of doubtful geological age, probably either Oxford clay or representatives of the Coralline Oolites.

A large map showing the geological structure of the Wealden area is suspended under the neighbouring Gallery.

AUSTRALIAN GOLD. *Case No.* 23.

Some fine specimens of rich gold-quartz from Australia, and models of Australian gold nuggets, are here grouped together.

Early references to the occurrence of gold in Australia go back to the year 1823, if not earlier, but the first notice by a scientific authority seems to have been due to Count Strzelecki. It appears that in 1839 he discovered traces of gold in New South Wales, but on relating the circumstance to the Governor, secrecy was enjoined for reasons of State policy. In 1841 the Rev. W. B. Clarke wrote to a friend in the colony, mentioning that he had found gold ore; but neither of those facts was published in the colony, and they were wholly unknown in Europe. The study of the auriferous tracts of the Uralian mountains enabled Murchison, in 1844, to predict the discovery of gold in Australia. It was not, however, until 1851 that public attention was attracted to the subject, when Mr. E. H. Hargraves announced the existence of an extensive gold-field, and thus led to the rapid development of the marvellous resources of the country.

GUN-FLINTS. *Case No.* 22.

This case contains a complete series of specimens illustrating the manufacture of gun-flints. They were collected by Mr. Skertchly when working, as an officer of the Geological Survey, in the neighbourhood of Brandon, on the borders of Suffolk and Norfolk. Brandon has always been the centre of the gun-flint industry, and Mr. Skertchly believed that the art of flint-working had survived in this district from prehistoric times. On the introduction of percussion-caps, the flint-knapping industry rapidly decayed, but there is always a demand for gun-flints for exportation to semi-civilised peoples, and the opening-up of remote parts of Africa has recently stimulated the trade.

The specimens here exhibited illustrate the various types of gun-flint; the successive stages in their manufacture; and the actual tools employed, many of which are curiously archaic in type. First the block of flint is quartered; then long flakes are struck off; and from these flakes, broken transversely, the gun-flints are trimmed—"knapping" being the technical expression for the final formation of the gun-flint.

Some tinder-boxes, with their flint and steel, and several other antiquated fire-producing appliances are here exhibited.

STONE IMPLEMENTS. *Case No.* 23.

Associated with the bones of many of the extinct mammalia of the pleistocene period there have been found great numbers of flint implements of contemporary age. A French antiquary, the late M. Boucher de Perthes, was the first to direct attention

to the occurrence of flint "hatchets" at considerable depths in the sands and gravels of the valley of the Somme. Some of these worked flints from Abbeville and Amiens are exhibited, with other flint implements from widely separated localities.

Several fine *palæolithic** implements from the high-level gravels between Herne Bay and the Reculvers, on the coast of Kent, found by Mr. Thomas Leech in 1860, are of special interest, inasmuch as they were the first implements found in this country after Boucher de Perthes' discoveries had called attention to the subject. Here also are some palæolithic implements found in gravel, while digging, in 1894, for the foundation of a building at the corner of Jermyn Street and Eagle Passage. A flint implement, occurring in brick earth, from near Brandon in Suffolk, said by Mr. Skertchly to pass under the chalky boulder-clay, is worthy of special attention, since, if the observation be correct and the beds were undisturbed, the implements might be assigned to an inter-glacial age.

The rudely chipped flints, occurring in the drift-gravels, are to be distinguished from the more highly finished *celts*, which, in most cases, bear evidence of having been carefully ground and polished: such stone weapons, by no means always of flint, are much more recent than the worked flints from the drift, being referable to that prehistoric era, known to archæologists as the *neolithic*,† or newer stone age.

For comparison with these ancient implements, and to explain their probable use, there are exhibited, in the opposite compartment of the Case, several examples of the rude stone implements used by certain savage tribes at the present day. A few flint arrow-heads, prepared to deceive collectors, are also placed by the side of the genuine relics.

Slab from a French Bone-Cavern.—*Presented by the late M. Lartet and H. Christy. No.* 24.

This slab of osseous breccia was obtained, by the donors, from the floor of the bone-cave of Les Eyzies, in the valley of the Beune, a tributary to the Vézère, in Dordogne. The bones are chiefly those of the reindeer, and are in most cases fractured, having probably been broken for the extraction of the marrow. These bones are associated with great numbers of worked flints, rolled pebbles, and fragments of foreign rocks, the whole being cemented together by stalagmitic carbonate of lime. The most interesting relics of human workmanship in these deposits are rudely-engraved pieces of bone and plates of schistose rock, which are among the earliest known specimens of the engraver's art. In the block before us there has been found a small bone needle, and a human tooth was detected in a similar slab sent to Vienna. The bone deposits of Dordogne are referable to a remote era, when the use of metal was apparently unknown,—an era some-

* Greek, *palaios*, old; *lithos*, stone. † *Neos*, new; *lithos*, stone.

times called by the French archæologists the *reindeer age*, in consequence of the presence of the reindeer in certain southern districts where it has not been found during the historic period. For information on the French bone-caves, the visitor should refer to Messrs. Lartet and Christy's *Reliquiæ Aquitanicæ*, edited by Professor T. Rupert Jones, 1875.

NEVILL COLLECTION. *Cases Nos.* 25 *and* 26.

Two Table Cases standing at the northern end of the Museum, one on each side of the large fluor-spar vase, contain a valuable collection of minerals formed many years ago by the late Mr. William Nevill, of Godalming in Surrey, from whom it was purchased by Mr. Henry Ludlam, who bequeathed it, with his other minerals, to this Museum. The collection includes many specimens of historical interest, such as those obtained from the Lettsom cabinets. In 1872 Mr. Nevill printed a descriptive catalogue of this collection, and it is from this catalogue that the printed labels attached to the specimens have been extracted. The arrangement is founded on Gustav Rose's crystallo-chemical system, and is very similar to that adopted at the British Museum. The collection comprises between three and four thousand specimens, of which only a small proportion can be displayed in the glass cases, the remainder being preserved in a series of 72 glass-covered drawers in the lower part of the cabinets.

LARGE VASE OF FLUOR-SPAR.—*Presented by the late S. Addington. No.* 27.

This handsome Vase is formed of a beautiful variety of Fluor-spar which occurs only at a single hill called Tre-cliff, near Castleton in Derbyshire. It is a mineral of finely-variegated purple tints, known locally as "Blue John," a name adopted by the Derbyshire miners to distinguish it from "Black Jack," or zinc-blende (p. 70). The Derbyshire spar was not known until the year 1770, but it has since been so largely employed for ornamental purposes that the true "Blue John" is no longer to be obtained. The spar rarely occurred in masses of large size, and hence the difficulty of procuring material for manufacturing so large a vase as that exhibited. This vase, which was made by Mr. Vallance, of Matlock, of several pieces of spar, is 2 ft. 8 ins. high, and its greatest circumference is about 3 ft. 7 ins.

METEORITES. *Case No.* 29.

Only a small collection of these fascinating objects—stones which have fallen from the sky—was formerly exhibited; but Mr. Ludlam's bequest some years ago brought into the possession of the Museum the splendid collection of Meteorites which was

originally made by the late Mr. Nevill, and purchased from him by Mr. Ludlam. This collection is here exhibited.

Scientific attention was first seriously directed to the study of Meteorites about a century ago by the researches of the German physicist—Chladni. It is now usually believed that they are small cosmical bodies circulating in space, and brought from time to time within the sphere of the earth's attraction. Many Meteorites have been seen to fall, but most specimens have been found as mineral masses on the surface of the earth, and have been regarded as meteoric in consequence of their peculiar composition. Some are composed mainly of iron, and others of various stony silicates; whence the common grouping of these bodies as *meteoric irons* and *meteoric stones;* the general term *meteorite* being used to include both groups.

The classification followed in arranging the meteorites in the Case is that adopted at the British Museum. Three groups are recognised; 1. *Siderites,** or *Aerosiderites,*† consisting chiefly of metallic iron, usually alloyed with more or less nickel, and associated with such minerals as schreibersite (phosphide of nickel and iron), troilite (meteoric pyrites), graphite, &c. 2. *Siderolites,*‡ which consist of a more or less continuous sponge-like mass of nickeliferous iron, having the cavities charged with various silicates, &c. 3. *Aerolites,*§ or meteoric stones, consisting generally of one or more silicates, interspersed with isolated particles of nickel-iron, troilite, &c.

AGATES. *Case No.* 30.

An agate is not a definite mineral, but rather an aggregate of various siliceous minerals, chiefly varieties of chalcedonic, jaspery and crystalline quartz. A large series of specimens, including some beautiful polished slabs, has been collected in this case. Some agates occur as veinstones, but by far the larger number are found in the cavities of certain igneous rocks, akin to basalt, but generally associated with palæozoic strata. It is probable that the disengagement of gas or steam produced pear-shaped cavities in the igneous rock when in a fluid condition, and that these hollows, retained by the viscosity of the lava-like rock, have since been filled, partially or entirely, by silica and other substances deposited upon the walls of the cavities from solution in the water circulating through the rock. Many of the specimens in this case were selected by the late Prof. Nöggerath, of Bonn, with the view of showing what he regarded as the inlets of infiltration through which the siliceous liquid may have gained access to the interior of the stone. Reference has already been made (p. 49) to the chief localities of agates and to the agate-industry which is centred at Oberstein. Most of the agates of commerce are now-a-days coloured by artificial processes, such as boiling them in oil or syrup, and subsequently

* Greek; *sideros,* iron.
† *Aer,* air; *sideros,* iron.
‡ *Sideros,* iron; *lithos,* stone.
§ *Aer,* air; *lithos,* stone.

treating them with sulphuric acid; the oil or sugar is absorbed into the more porous layers, and then carbonized by the action of the acid. By first boiling agates in solution of sulphate of iron (ferrous sulphate) and then exposing them to heat, by which peroxide of iron is formed, red varieties may be produced. By various other chemical processes the agates may be stained of a blue, green, or yellow colour. (*See also* p. 113.)

Illustrations of Fossilisation. *No.* 34.

A collection of specimens has been made with the view of illustrating the various ways in which organic bodies may be more or less perfectly preserved as fossils. The series starts with some examples of the hard parts of *vegetable* structures capable of preservation, such as the fibro-vascular tissues of "skeleton leaves"; and then passes to the hard structures of *animals*, such as the internal pen of the cuttle-fish, and the external shells of most mollusca. Certain organisms, however, are practically destitute of any structures capable of being permanently preserved, and are consequently represented in the rocks only by impressions or casts, as illustrated by the worm-tracks and fucoid-markings here exhibited.

Under certain conditions the original organic structure may be preserved, either wholly or partially, with little or no alteration; as well seen in the insects in amber, and less perfectly illustrated in the preservation of vegetable matter in the form of peat. The organic structure, in other cases, suffers molecular replacement, in whole or in part, by mineral matter, but its internal texture is represented more or less perfectly. This is a very common mode of fossilisation, and is illustrated by a wide range of specimens, showing mineralisation not only by common species—such as quartz, calcite and pyrites—but by minerals not usually concerned in fossilisation: here, for instance, are structures preserved in hæmatite, galena, sulphur, &c.

It often happens that while the original organism has been wholly removed by decomposition, the external form has been preserved either as an impression or *mould*, or as a solid *cast*; while in certain cases, as in some of the "box-stones" of the Suffolk Crag, both mould and cast may be present. The series is brought to a conclusion by a small group of specimens, showing how fossils may suffer distortion by mechanical pressure, as often seen in rocks in which slaty cleavage is developed.

Pseudomorphs. *Case No.* 37.

The mineral collection bequeathed by Mr. Ludlam, contained a large suite of specimens illustrating the phenomena of pseudomorphism, or the replacement of one mineral by another with retention of the original form. This collection is here

exhibited. The series commences with examples of the *incrustation* of one mineral by another, forming pseudomorphs by simple mechanical investment. By far the larger number of pseudomorphs, however, are due to chemical alteration; the action consisting, as here illustrated, either in the *loss* of a constituent (*e.g.*, native copper in form of cuprite, by removal of oxygen) or in the *gain* of a constituent (*e.g.*, malachite after cuprite, by addition of carbonic acid), or in the *exchange* of one constituent for another (*e.g.*, pyrites converted into limonite, by loss of sulphur, and gain of oxygen and water). Finally, the change may be so profound that the secondary mineral is entirely distinct in composition from the one which it replaces, as seen in such a case as that of the replacement of calcite (carbonate of lime) by quartz (silica). A few examples of the mineralisation of organic structures form a link between this case and the objects in the adjacent one, No. 34.

Volcanic Products. *Case No.* 39.

This Table Case contains a collection of minerals and lavas, chiefly from Vesuvius and Etna, which were formerly exhibited with the rock-specimens in the Upper Gallery, but were removed some time ago, in consequence of lack of space. Each specimen is furnished with a label, recording the name of the substance and its locality.

Precious Metals, Aluminium, &c. *Case No.* 35.

A rather miscellaneous assemblage of metallurgical specimens is exhibited for convenience in this case.

The series of *precious metals* includes not only specimens bearing on the production and applications of gold and silver, but also samples of such metals as platinum and palladium. *Platinum* was discovered in 1735, by a Spanish traveller, who obtained it from certain river-deposits in New Granada. It was afterwards discovered, also in alluvial detritus, in several other localities, especially in the Ural Mountains. After Wollaston, in the early part of the century, had suggested a method of treating the metal, so as to render it useful in the arts, the Russians turned their attention to platinum as a metal of economic importance, and soon afterwards issued platinum coins. The metal is shown in the finely-divided form of *platinum black*, in the cellular condition of *spongy platinum*, in massive form as fused by the oxyhydrogen blow-pipe, and in the state of foil and wire.

Aluminium was obtained in the condition of a powder, by Wöhler, as far back as 1827, but it was not until Henri Sainte-Claire Deville produced it, in 1854, in the form of bars, that the metal acquired any industrial importance. Aluminium may be readily obtained from *Cryolite*—a mineral found in Greenland,

and consisting of a double fluoride of aluminium and sodium, which, when heated with metallic sodium and common salt, yields aluminium. Another source of the metal is found in *Bauxite*, a mineral orginally obtained from Beaux, in the south of France, and composed chiefly of alumina and peroxide of iron. A series illustrating the preparation of aluminium from bauxite, as formerly carried on at the Washington Aluminium Works, is here exhibited. By heating a mixture of bauxite and soda-ash an aluminate of soda is obtained, and from a solution of this salt, alumina in the state of hydrate may be precipitated by an acid. A mixture of this precipitated alumina with common salt and charcoal is treated with chlorine, and from the double chloride of aluminium and sodium thus formed, metallic aluminium is obtained by the reducing action of sodium.

At the present time aluminium is largely obtained by various electrical processes. In Cowle's method, a mixture of alumina, carbon and copper is subjected to the current of a powerful dynamo, whereby an alloy of aluminium and copper is obtained, forming the well-known *aluminium bronze*, which has been rather extensively used for ornamental purposes.

Magnesium is a metal which may be prepared by the action of sodium, at a red heat, on chloride of magnesium; and it has also been obtained by the electrolysis of the chloride. Its specific gravity is 1·74, that of aluminium being about 2·6.

Cadmium is a somewhat rare metal, extracted from the zinc smelted from cadmiferous blende. Specimens of metallic cadmium are shown in the form of ingot. An amalgam of cadmium is used in dentistry. The sulphide, known as *cadmium yellow*, is employed by artists, while the iodide is used in photography.

Bismuth is a metal which occurs mostly in a native state. The ready fusibility renders its metallurgical treatment exceedingly simple, the metal being readily separated from any foreign matters by fusion. Some singularly beautiful examples of bismuth, crystallised artificially, are introduced. The iridescence is said to be given to the surface by the regulated action of heat. Bismuth is used in the formation of *type metal, pewter, solder*, and *fusible metal*. An alloy of bismuth 8, lead 5, and tin 3, will melt at a temperature lower than that of boiling water.

Antimony is a brilliant crystalline metal, extremely brittle, obtained mostly from the sulphide, known as *stibnite*. The crystalline structure is well shown by the fern-frond pattern on the surface of a cake of "star antimony."

A curious old *antimony cup* is here exhibited. When wine was allowed to stand in such cups, tartarised antimony (*tartar emetic*) was formed and dissolved, and consequently when the wine was drunk it produced sickness.

A *gilt copper cup* obtained from the copper mine of Herrngrund in Hungary, by alteration of an iron cup, is also shown

If iron is placed in a solution of sulphate of copper, the iron is dissolved as sulphate of iron, and copper takes its place. This process is termed *cementation,* and the cup exhibited was thus produced, the mine-water containing copper sulphate. The inscription on the cup is *Gott zeigt an Mir sein grose Macht der auss Eisen Kupfer Macht,* "God shows in me his great power, who out of iron makes copper." The date of this cup is about 1650.

Some examples of *tin plate,* with a series illustrating the process of manufacture, are exhibited. Tin-plate is iron, or steel, coated with a thin layer of tin. The iron, which must be manufactured with much care, is rolled into sheets of the required thinness. Mild steel is now commonly used in place of iron. The sheets are cut into rectangular pieces, and these are freed from adhering oxide, or any impurities which would inevitably prevent the adhesion of the tin, by pickling in a bath of sulphuric acid. They are withdrawn, and after washing, are annealed in the furnace. The plates are passed through cold iron cylindrical rollers, and then, after another annealing, are exposed to the action of dilute sulphuric acid, until they become perfectly bright. Being cleaned off, the plates are passed through hot palm-oil, and then plunged into melted tin, covered with grease, or with zinc chloride, and the surface thus becomes alloyed. The plates are subsequently dipped into another pot of metal, then passed between steel rollers, and finally cleaned off and polished. *Terne plate* is coated with an alloy of tin and lead, instead of with pure tin.

Electro-Metallurgy.—*Case No.* 32.

Large Electrotype Busts—Nos. 5 *and* 45 (*near the Stairs to Gallery on each side*).

The earliest discovery of the process of electro-metallurgy, was announced to the public on the 4th of May 1839, by Professor Jacobi, of St. Petersburg. On the 8th of May, Mr. Spencer announced to the Liverpool Polytechnic Institution his discovery; and on the 22nd of the same month Mr. C. J. Jordan published in the Mechanics' Magazine a description of his method. Some beautiful exampes of electro-deposited metals are collected in this case, and several others are placed on the neighbouring walls. Many surfaces, such as clay, plaster of Paris, wax, &c., are not conductors of electricity, and consequently upon these metal cannot be precipitated. The late Mr. Robert Murray discovered that black lead (*plumbago*), rubbed over such articles gave them at once a conducting surface, and rendered them fit for receiving, by the voltaic battery, a metallic precipitate. Thus are formed several of the objects exhibited.

If silver or gold is to be deposited, preparations of these metals are dissolved in cyanide of potassium or some such salt. The article is immersed in this, and when connected with the

battery, silver or gold is deposited. This is electro-plating. To prevent the silver from presenting a granular or dead appearance, a few drops of bisulphide of carbon may be added to the solution.

The botanical specimens, &c., of which there are exhibited electrotype coatings, may be prepared by first dipping the grass or leaves into a solution of phosphorus in bisulphide of carbon, and then plunging the article into a solution of nitrate of silver. The thin film of phosphorus left upon the surface occasions a precipitation of a finely-divided coat of silver, upon which, when connected with the battery and placed in the proper solutions, any quantity of either copper, silver, or gold can be deposited.

Some of the most interesting results of electro-metallurgy have been the coating of iron with copper, and the electro-chemical deposition of the compound metal, brass, of which some examples are shown. An important application of electro-metallurgy on a large scale has been the electro-deposition of nickel or various metals. The nickel may be thrown down from a solution of a double salt, such as a double sulphate of nickel and ammonia. The process is now largely worked in London and Birmingham, and specimens are exhibited, showing the deposition of nickel on slabs of copper, tin, cast-iron, steel, brass, and German silver.

PHOSPHOR-BRONZE.—The upper shelves of this Case (No. 32), on the opposite side to that containing the electro-metallurgical series, are devoted to the exhibition of specimens of this alloy, presented by the Phosphor-bronze Co., Limited. Experiments have shown that the alloy formed by adding phosphorus to bronze in certain proportions, possesses valuable mechanical properties; and its manufacture has consequently been established in this country. The manifold applications of phosphor-bronze are well illustrated by the specimens exhibited in the case before us.

CHINESE BRONZES, &c. *Case No.* 36.

The Chinese and Japanese exhibit very great ingenuity in the preparation of alloys, and in their modes of casting. In many instances the model is most carefully made in wax, and all the ornamentation, inscriptions, and the like elaborately finished; this is then covered with the clay which is to form the mould, and when dry the wax is melted out; the metal which subsequently in a fluid state supplies its place fills every part, and thus is obtained a casting of great sharpness and correctness. Casting by the *cire perdu* process is now practised in this country.

The *gongs* and *tam-tams* of the Chinese are forged with the hammer, as indeed are many of their bronze articles. The composition of these appears to be 82 per cent. of copper and 17 of tin, with small quantities of iron and nickel. The most celebrated locality for making gongs is Su-tchou.

Some of the *Chinese mirrors* possess the very remarkable property of reflecting from their polished surface the figure which is wrought upon the back. The cause of this has been studied by Profs. Ayrton and Perry, who refer it to slight inequalities of superficial curvature, produced by the buckling of the bronze during manufacture.

In this Case there is also exhibited a small collection of the principal alloys used by the Japanese in their art metal-work. These present a great range of colour, some of the tints being extremely beautiful. The use of peculiar pickling solutions developes the superficial stains and patina exhibited by certain of these alloys.

A large number of analyses of oriental metal-work, including many Japanese alloys, in the South Kensington Museum, have been made under the direction of Prof. Roberts-Austen, and published by the Department of Science and Art (1892). For information on Japanese bronze casting, the visitor may refer to Mr. W. Gowland's paper in the Journal of the Society of Arts, May 1895, p. 523.

Art Applications of the Metals. *Case No.* 42.

The objects grouped in this Case serve to show the characters of the metals in a pure and in a mixed state, and to illustrate their application to works of art and to art manufacture.

Statuettes in tin and copper show the characters of the metals in their ordinary states. One in *brass* exhibits the result of combining copper and zinc, while those of Raphael and Michael Angelo are bronzes, in the proportion of 90 parts of copper and 10 of tin. The statuette of Humboldt is of *zinc*, but it has been subsequently coated by the electro-chemical process.

The *silver and bronze vases* are copied from antique specimens found in Pompeii, and now preserved in the Museum at Naples. *Corinthian bronze*, in which one of them is cast, consists of two-thirds copper and one-third silver. This composition is said to receive its name from its having been discovered by the accidental melting together of statues of copper and silver which were destroyed by fire at Corinth. *Electrum* was one of the celebrated mixed metals of the ancients, of which we have here an example. Our *standard silver* (*see* Silver Vase) has a composition of 222 silver and 18 copper; by the admixture of the latter metal the required hardness is obtained without interfering with the colour of the silver.

Among the miscellaneous objects placed against the walls on this floor is a fine old *Flemish Monumental Brass*, near Case 42. This brass forms part of the mixed-metal series exhibited. It is of Lodewyc Cortewille, of Cortewille, near Liége, who died in 1504, and of his wife Colyne van Castre, who died 1496. The analysis made in this establishment shows its composition to be—Copper, 64·0; Zinc 29·5; Lead, 3·5; Tin, 3·0.

Ornamental Iron Castings. *Case No.* 6.

Some fine examples of the use of iron in art manufacture, and for the reproduction, in durable material, of works of high art, are here exhibited. Such productions are coloured either by the application of a resinous paint or by a process of bronzing, which may be effected by the application of *chloride of platinum*, of the *salts of copper and iron*, and by other means, one of these being the deposition of thin coats of copper or brass by the electrotype process.

Some beautiful specimens of the delicate *Berlin Castings* are in this Case. At the time when the final struggle commenced between Prussia and Napoleon, the patriotism of the Prussian ladies was particularly conspicuous. With the noblest generosity they sent their jewels and trinkets to the Royal Treasury, to assist in furnishing funds for the expenses of the campaign. Rings, crosses, and other ornaments of cast iron given in return to those who made this sacrifice, bore the inscription, *Gold für Eisen* (gold for iron), and such Spartan jewels are, to this day, much treasured by the possessors and their families. This led to the production of ornaments far more delicate than anything which had heretofore been manufactured; and these becoming known and admired in every part of Europe, an extensive trade in them speedily arose.

The Castings intended for use in Bookbinding, the Cast Iron Fan Necklace, and Bracelets, from the iron works of the Count of Stolberg-Wernigerode, at Ilsenburg, Hartz Mountains (Magdeburg), are fine examples of this manufacture.

The large circular ornamental casting, with the sand attached, as it was taken from the mould, shows the perfection to which the processes have been brought. It has been thought that much of the beauty of these castings depends upon the sand employed in forming the moulds.

Manufacture of Spiegeleisen, &c. *Case No.* 8.

One half of this Table Case, near the bust of Melpomene, is devoted to illustrations of the manufacture of Spiegeleisen, mostly presented by Mr. H. Bauerman. Spiegeleisen is a highly crystalline variety of white cast iron, rich in carbon and manganese, and exhibiting on fracture brilliant mirror-like cleavage-planes. Its manufacture has acquired considerable importance from its use in the Bessemer and other processes of steel-making. When the carbon has been completely removed from the cast-iron, a proper quantity of spiegeleisen or of ferro-manganese is introduced into the Bessemer converter, and thus the required proportion of carbon can be added with great precision. The spiegeleisen is largely smelted from the spathic iron ores, or carbonate of iron, of the Siegen district in Westphalia, and is also manufactured from similar ores in Styria; whilst, in this country, suitable materials are furnished

by the spathose ores of the Exmoor hills in Devonshire, the Brendon hills in Somersetshire, and Weardale in Durham. Spiegeleisen is also obtained in some of the Continental works from manganesiferous hematites, and it is likewise smelted from the residues obtained in the treatment of mixed ores of iron and zinc at Newark in New Jersey. The latter process is well illustrated in the Case before us. After the greater part of the zinc has been removed from the ore, the cinder-like residue is smelted for spiegeleisen. This residue contains all the iron and manganese originally present in the franklinite, one of the chief minerals in the mixed ore. The bright green colour of the slag accompanying the spiegeleisen is due to the presence of manganese. The proportion of manganese in the spiegeleisen varies considerably in different specimens; one example exhibited, from Laibach in Carniola, contains as much as 14 per cent. If the proportion exceeds 20 per cent. the alloy is known as *ferro-manganese,* which is used for the same purposes as spiegeleisen. In ferro-manganese the proportion may rise to nearly 90 per cent.

On the opposite side of this Case will be found a series of specimens illustrating the smelting of the brown iron ores of the Coral Rag—one of the sub-divisions of the series of middle oolites—as carried on at Westbury in Wilts.

A portion of this Case is temporarily occupied by specimens showing the powerful agglutinating action of oxide of iron.

Slags and Crystalline Furnace Products. *Case No.* 12.

Among the more notable specimens of crystalline products in this Case, attention may be directed to some fine examples of the bright copper-red cubic crystals of a peculiar compound of *titanium* (p. 71), not unfrequently found in the "bear" of blast furnaces. These crystals were formerly thought to be pure titanium, but are now known to consist of nitride of titanium with cyanide of titanium. The specimens of crystallised *oxide of zinc* from the iron furnaces of Westbury are also interesting. The fine specimen of a furnace-product having the composition of magnetic oxide of iron and exhibiting an aggregate of octahedral crystals, will not fail to catch the visitor's eye; nor will the other artificial minerals escape attention, such as the crystals of galena from the Freiberg lead furnaces, or of orthoclase from the Hartz copper-works. There is also exhibited here a beautifully crystalline compound of peroxide of iron and lime, thus related in composition to the natural group of spinels, which was prepared by the late Dr. Percy.

The opposite half of this Case contains some interesting forms of *slag*, several of which are crystallised; in some cases these resemble, both in form and in composition, certain minerals. The utilisation of iron-slags from blast-furnaces is illustrated by specimens showing their use for making concrete and cement, for ornamental castings and for the production of

"slag wool." Some interesting specimens of old slag from the Weald carry us back to the days when iron was smelted in Kent and Sussex. A series of specimens in this Case illustrates a process used at one time by Messrs. Chance, of Birmingham, for melting the Rowley rag, a basaltic rock occurring in South Staffordshire, and casting it in moulds for tiles and architectural ornaments. It is interesting to note, from these specimens, that when the product cooled rapidly it formed a vitreous mass like obsidian, whereas if cooled slowly it soldified as a hard stony substance.

SWEDISH IRON AND STEEL, COPPER, &c. *Cases Nos.* 15 *and* 18.

It is well known that iron of a very superior quality, much valued for steel manufacture, has long been produced from the iron ores of Sweden. These consist chiefly of the magnetic and red oxides, which are classed together as "mountain ores," to distinguish them from the brown oxides, which occur in the shape of "lake-" and "bog-ores," and yield an inferior kind of iron employed chiefly for castings. The mountain-ores are calcined usually in kilns heated by the waste gases from the blast furnace, and are smelted exclusively with charcoal. It is to the employment of this fuel, and to the freedom of the ores from phosphorus, that the Swedish iron owes its superiority. The greater part of the pig iron is converted into malleable iron in refineries, or hearths, heated with charcoal.

The Table Case No. 15 is entirely devoted to specimens of Swedish iron and steel, and a large part of No. 18 also contains examples of these metals and of the ores from which they are produced. But the visitor will also find in Case 18 a number of other Swedish metallurgical products, including a series illustrating the extraction of nickel at Klefva in Småland; the smelting of lead at Sala and the production of copper at Falun. The mines, or rather open workings, at Falun, in Dalecarlia, are of great antiquity, and yield large quantities of copper- and iron-pyrites, but the workings are of much less importance now than they were formerly.

SWORDS AND GUN-BARRELS. *Case No.* 13.

Swords.—The oriental sword blades have always been celebrated, and their superior character has been referred to the excellent iron ores which are obtained in various parts of Asia, and to the reduction of those ores by charcoal. The finest oriental sabres are those, professedly of great antiquity, presumed to have been made at Damascus in Syria, at Ispahan in Persia, and at Cairo in Egypt. The characteristics ascribed to the real Damascus blades are, extraordinary keenness of edge, great flexibility of substance, a singular grain of fleckiness always observable on the surface, and a peculiar musky odour

given out by any friction of the blade, either by bending or otherwise.

Toledo under the Romans, and in the time of the Moors, was celebrated for the admirable temper of its swords, "which is chiefly attributable," says a writer on the Toledo blades, "to some favourable quality in the water of the Tagus, used in "tempering the steel."

Andrew of Ferrara has associated his name with the swords of his manufacture, "Andrea Ferrara." This sword maker was considered, in his time, to be the only man in Great Britain who knew how to temper a sword in such a way that the point should bend to touch the hilt and spring back again uninjured. He is said to have resided in the Highlands of Scotland, where he employed many men in forging his swords, devoting his entire attention to tempering them. This operation he performed in a dark cellar, the better to enable him to distinguish the colours produced by heat on the blade, upon which everything depended.

Swords appear to have been made at Birmingham from a very early period, and sword-making is now one of its staple trades. The forges of Sheffield, however, furnish a large quantity of bars of steel, called *sword moulds*. One of these is shown, as also the fastening of the *tang*, which is of iron; and the results after the different stages of forging. It is hardened by heating it until it becomes *worm red*, and then dipping it, point downwards, in a tub of cold water. It is tempered by drawing it through the fire several times, until it exhibits a bluish oxidation on the surface. It is subsequently polished and mounted.

Manufacture of Gun-barrels.—The principal object sought in the manufacture of a gun-barrel is its strength. It should possess so much tenacity as will ensure its resisting the sudden shock to which it is exposed in projecting the ball by the explosive force of gunpowder. The series here exhibited illustrates only the old method, now largely superseded. *Scrap iron* is employed for inferior barrels, *horse-shoe nails* and *scrap steel* are (or were) taken for superior kinds; these are welded into flat bars; the bars of iron and steel are again welded together, and formed into square bars. If a number of straight bars were welded together to form a barrel, they would be liable to open along the lines of welding; at all events, such a gun-barrel would not be nearly so safe as one made of the same bars formed into a helix and then welded into a tube.

By altering the arrangement of the fibres of the iron there is produced a different pattern on the surface of the barrel, when they are rendered visible by polishing. Thus, one bar is twisted to the right, another is twisted to the left hand. Now these when twisted on a mandril are welded into a barrel, which will exhibit an involved pattern. If they are combined, or if an untwisted bar is placed between them, and they are then

turned and welded, we have a still more elaborate pattern as the result. Gun barrels are now largely made of mild steel.

The lower part of this Case is occupied by some fine examples of Bessemer steel from the Exhibition of 1862, presented by Sir Henry Bessemer.

Illustrations of the Physical Properties of Metals. *Case No.* 14.

A collection of specimens is here exhibited to illustrate the physical properties of metals, especially their malleability and ductility, and to show the advantage which is taken of such properties in applying metals to purposes of ornament. *Malleability* is the property of permanently extending without fracture when the substance is subjected to pressure, as in rolling, or to impact, as in hammering. The great malleability of copper is well shown by a penny-piece rolled out to a length of ten yards. Excellent illustrations are also furnished by Messrs. Tylor's series showing the successive stages in the manufacture of a vase by hammering it into shape from a flat sheet. The large central ewer, of French manufacture, in the style of the Italian Renaissance, shows how copper admits of being beaten up; and there are likewise examples of *repoussé* work in silver. Specimens are also exhibited of copper sheathing, rolled zinc, sheet cadmium, "paper iron," gold leaf, and various foils.

Ductility, or the property of permanently extending, without rupture, when the substance is subjected to a pulling force, as in wire-drawing, is a property closely connected with malleability. Some examples of gilt silver wire, contributed by Messrs. F. and E. Stanton, are interesting as showing the great extension of which gold and silver are capable.

There are also in this Case several coins and medals, showing the sharpness with which certain metals receive impressions when stamped. The old process of *silver-plating* is likewise illustrated.

Large Mineral Specimens. *Cases Nos.* 21 *and* 31.

Several fine mineral specimens, too large for exhibition in the wall-cases, are displayed in two Pedestal Cases, one on each side of the Museum. Case 21 contains, in the upper part several magnificent examples of Australian *malachite*, or green carbonate of copper; whilst in the lower part attention may be called to a cleavage plate of *selenite*, of exceptional size and transparency, from a huge geode known as Selenite Mound, in Wayne Co., Utah,—a mound which was explored by Dr. Talmage, of Salt Lake City, who presented this and other specimens of selenite.

In the opposite Case, No. 31, are some very fine examples of *British lead-ores*, chiefly from the great Exhibition of 1851. The eye of the visitor will also be arrested by some beautiful specimens of *Japanese stibnite*, or sulphide of antimony.

THE MINERAL COLLECTION.

The Mineral Collection of this Museum is arranged in the series of 56 Wall Cases around the Principal Floor, and in the large Horseshoe Case occupying a prominent position in the central area. Apart from this general collection there will be found on the same floor a few mineral specimens, which have been isolated on account either of their size or of some special interest attaching to them.

The so-called *Non-metallic minerals* occupy the central Horseshoe Case, and are described at p. 101, while the *Ores* or *Metalliferous minerals* are placed in the series of Wall Cases, and arranged in the following order:—

British ores (west side) -	Cases	**1** to **14,**	p. 66.
British ores (east side) - -	„	**43** „ **56,**	„ 74.
Foreign ores - - -	„	**15** „ **23,**	„ 77.
Colonial minerals - - -	„	**37** „ **42,**	„ 89.
Mineral veins - - -	„	**24** „ **36,**	„ 85.

BRITISH ORES. Western Side. *Wall Cases* 1 to 14.

Copper.

Case **1.**—Although there is evidence that copper ores were worked in Anglesey by the Romans, yet the copper mines of this country are not as a rule of ancient date. In the last century, several tin mines were abandoned when the miners came to the *yellows*; that is, the yellow copper ore, and their saying was that the "yellows cut out the tin."

The series of copper-producing minerals exhibited in this collection commences with the valuable *Native, virgin,* or *malleable copper.* In many of the Cornish mines this mineral is not unfrequently found in company with various copper ores; the largest masses occurring in the serpentine of the Lizard district, of which a magnificent example will be seen in the Hall (No. 99, p. 43). The Irish and Scotch specimens on the top shelf of Case **1** show its occurrence in thin plates in the fissures of trap-rocks; whilst many other examples in the same case exhibit the characters of the crystallised varieties.

From native copper we pass to the sub-oxide known as *Cuprite* or *red copper ore,* a mineral containing nearly 90 per cent. of copper. It occurs often in octahedral or eight-sided crystals, of a fine ruby colour and high lustre, and occasionally assumes delicate capillary or hair-like forms, known to the miner as "*plush copper ore,*" and to the mineralogist as *Chalcotrichite*; whilst the less pure brick-red massive varieties of cuprite are often distinguished as *tile ore. Melaconite* or *black oxide of copper* is a dull blackish mineral substance, resulting from the decomposition of other copper ores.

Case **2**.—Well known from its employment sometimes for ornamental purposes, and sometimes as a pigment, the beautiful mineral called *Malachite* or *green carbonate of copper*, naturally claims attention. In this country, however, it is found only in subordinate quantity. Its recent formation is illustrated by the specimens from Wheal Leisure, in which particles of sand from the sea-shore are cemented by this mineral. With these specimens may be noticed the examples of cupriferous sandstone and conglomerate from the Lower Keuper of the neighbourhood of Alderley Edge in Cheshire. Among the carbonates of copper will be found a few specimens of *Azurite* or *blue malachite*, and on the same shelf are some samples of *Chrysocolla*, or hydrous silicate of copper.

In the series of arsenates of copper from Cornwall, attention may be directed to the beautiful sky-blue octahedrons of *Liroconite;* the dark blackish green crystals of *Clinoclase;* the bright emerald-green six-sided plates of *Copper mica;* the dull green crystals of *Olivenite*, and the fibrous variety of the same species known, from its structure, as *wood arsenate of copper*. With these are associated some specimens of *Libethenite*, or phosphate of copper, and a sample of the basic sulphate of copper from Cornwall, described by Professor Maskelyne, under the name of *Langite*. Here also will be found specimens of Professor Church's *Woodwardite*, an uncrystallised mineral of fine blue colour containing sulphate of copper and hydrate of alumina.

From these somewhat rare minerals we turn to the important ore, known as *Copper glance, vitreous copper*, or *Redruthite*, a disulphide of copper containing 80 per cent. of metal. From St. Ives and St. Just several fine crystallised specimens are exhibited, and in some of them will be recognised the peculiar six-sided forms which have suggested the popular name of "*nailhead copper ore*."

Cases **3, 4, 5, 6**.—Far exceeding all other copper ores in its importance to this country is the well-known *copper pyrites*,—the *yellow ore* of the miner, and the *Chalcopyrite* or *Towanite* of the mineralogist. This mineral, which is a sulphide of iron and copper, is usually found massive, but occasionally occurs crytallized, its characteristic forms being well shown by the specimens in Cases **3** and **4**. The fine mammillated and botryoidal masses from Cornwall and Devon are known to the miners as "*blister ore*"; whilst the iridescent tarnish on the surface of other varieties of copper pyrites has suggested the name of "*peacock ore*."

Case **7**.—Allied in chemical composition to copper pyrites, with which, indeed, it was long confounded, is the species called *Bornite, purple copper ore*, or *erubescite*. To our Cornish miners the mineral is commonly known as "*horseflesh* ore," whilst frequently it passes under its German name of *Buntkupfererz* (variegated copper ore).

The crystallised specimens of the Cornish mineral *Tennantite*—a sulphide of copper, iron, and arsenic, of somewhat rare occurrence—are followed by those of *Fahlerz*, or *grey copper ore*, a species which, although uncommon in this country, occurs near Liskeard in fine crystals, which exhibit well the characteristic tetrahedral forms which have gained for this mineral the name of *Tetrahedrite*. The series of copper ores is brought to a conclusion by the specimens of *Endellionite* or *bournonite*, an antimonial sulphide of copper and lead, of which some magnificent crystals of well-defined rhombic form, and remarkably high lustre, are exhibited from Liskeard in East Cornwall.

TIN.

Case **8.**—From the earliest recorded times Britain has been famous for its tin. The Cassiterides, or "Tin islands" of the historian, have been thought by some to be the Scilly Islands; but in all probability the name was given by the early navigators to the western part of England where we find evidences of mine-workings of the highest antiquity.

Diodorus Siculus describes the trade with Cornwall, "Bolerion," for tin, and mentions the place of shipment,—the Ictis, an island adjoining to Britain. He says, "It is something peculiar that happens to the islands in these parts, lying between Europe and Britain; for at full-tide, the intervening passage being overflowed, they appear islands; but when the sea returns a space is left dry, and they are seen as peninsulas." The late Sir G. C. Lewis supposed the Isle of Wight to be the Ictis, but it does not fulfill the conditions of the geographer: whereas St. Michael's Mount and Looe Island in all respects agree with the description.

Tin is almost exclusively obtained from *Cassiterite* or *tin-stone*, a peroxide of tin containing nearly 80 per cent. of metal. In the granite and clay-slate of Cornwall and Devon this mineral occurs in veins, and is readily separated from its gangue, or matrix, and from most of its accompanying minerals, by taking advantage of the great density of the ore. With the specimens of tin-stone will be found several pseudomorphous crystals, in which the original felspar of a porphyritic granite has been removed, and oxide of tin has taken its place, preserving still the true felspar form.

During the lapse of ages the tin-bearing rocks have been worn down by the combined influence of air and water, and the contents of the mineral lodes have been carried down to the lower grounds, and deposited as alluvial detritus. Specimens of such *stream tin* are exhibited from several Cornish localities, and with them are some examples of the fibrous varieties of tin-stone, known from their peculiar structure as "*wood-tin*," and *toad's-eye tin*."

Case **9.**—On the first shelf of this Case are placed several samples of *Stannine*, known also as *tin pyrites* and *bell-metal*

ore; a mineral containing sulphur, tin, copper, iron, and frequently zinc. This mineral is confined in Cornwall to a few localities, where it has been raised as a tin ore to a limited extent.

Tungsten.

Case **9.**—This metal, known also as *wolframium*, occurs usually as a double tungstate of iron and manganese, forming the species called *Wolfram.* Having a density corresponding nearly with that of tin stone, it is with difficulty separated from the tin ore with which it is almost invariably associated. It has for many years been raised at East Pool Mine in Cornwall. The yellow mineral called *Wolframine* is a tungsten ochre: whilst the rare species *Scheelite* is a tungstate of calcium.

Bismuth.

Case **9.**—This metal, which occurs usually in a native or free state, is not found in this country in any considerable quantity. In Cornwall its ores occasionally occur associated with other minerals,—with tin in St. Just, and with copper in Redruth and in the Camborne mines.

In addition to the samples of *Native bismuth*, of which some are remarkable for their brilliant lustre, will be found several specimens of *Bismuthine*, a sulphide of bismuth, and of the rare mineral called *Aikenite* or *Needle ore* a sulphide of bismuth, copper, and lead. It is noticeable that bismuth and its ores are characterised by their extreme fusibility, melting readily even in the flame of a candle.

Cobalt and Nickel.

Cases **9** and **10.**—The ores of these allied metals will be more fully noticed among the foreign minerals. In this country they are occasionally found in Cornwall, Cumberland, Flintshire, and Scotland, but the amount is neither considerable nor constant. The principal cobalt ores are *Smaltine*, or tin-white cobalt, and *Cobaltine*, or silver-white cobalt; the former an arsenide, and the latter an arsenio-sulphide of cobalt, but both usually containing varying proportions of other metals. The decomposition of these arsenical cobalt ores produces the peach-blossom coloured arsenate known as *Erythrine* or *cobalt bloom.*

Among the nickel ores, of which the principal is the di-arsenide known as *Kupfernickel* or *copper nickel*, attention may be directed to the needle-like crystals of *Millerite* or *capillary pyrites*,—a sulphide of nickel occurring in the cavities of the clay-ironstone nodules of South Wales.

No nickel ores are at present worked in this country. The only cobalt-ore recently raised has been some impure ore from the Carboniferous Limestone of Flintshire, but even this is no longer obtained.

Zinc Ores.

Cases **11** and **12.**—The most widely-diffused ore of this metal is the sulphide called *Zinc blende*, from the German *blenden*, to dazzle, in allusion to the high lustre which this mineral often presents. Blende is generally associated with the ores of lead, and frequently with those of copper and tin. In a state of purity it is transparent and almost colourless, as seen in some of the specimens in this case; but generally the blende of this country is mixed with a variable amount of sulphide of iron, which imparts to it a dark colour, whence it is called by the English miners *Black Jack*. In some districts the presence of zinc is deemed by the miners unfavourable, and they speak of "Black Jack cutting out the lode." In others it is thought to be a favourable indication, and we often hear that "Black Jack rides a good horse."

More valuable as an ore, but much less abundant than the sulphide, is the carbonate of zinc usually known as *Calamine*. This mineral rarely occurs crystallized, but is usually found in deposits of mammillated, botryoidal, and stalactitic forms, of which some fine examples are exhibited from Alston Moor.

The hydrous silicate of zinc, known as *Smithsonite* or *electric calamine*, commonly occurs associated with the carbonate, with which it is not unfrequently confounded. Attention may be directed to a fine specimen of a blue cupreous variety of this species from Cumberland.

Cadmium.

Case **12.**—With the ores of zinc will be found some specimens of the rare Scotch mineral called *Greenockite*, which is a sulphide of cadmium occurring in yellow lustrous crystals of hexagonal form. The usual sources of cadmium and its applications have been noticed at p. 57.

Manganese.

Case **13.**—Although not occurring in this country in regular deposits or in very considerable quantity, the ores of manganese have, however, been worked in several localities near Tavistock, and at Launceston, at several mines not far from Exeter, in the Mendip Hills, and in Warwickshire.

Manganese is employed in glass manufacture as a decolouring agent, in the manufacture of pottery as a pigment, and it is likewise used in the manufacture of Spiegeleisen and ferromanganese. In the preparation of chloride of lime and in bleaching, manganese is very largely used, being employed for the purpose of liberating the chlorine from the hydrochloric acid or the salt (chloride of sodium) with which it is mixed for this purpose.

Pyrolusite, or binoxide of manganese, has received its name from the Greek (*pur, fire* and *luō, to wash*) in allusion to its

employment as a decolouring agent in glass manufacture, and for the same reason it has been called "glass makers' soap."

Manganite, or *grey manganese ore,* is a hydrous sesquioxide, of much rarer occurrence in this country than pyrolusite; whilst the somewhat ill-defined species *Psilomelane* is an impure hydrous oxide, usually found in botryoidal or stalactitic forms, which from their *smooth* surface and *black* colour have given the name to this species.

Uranium.

Case **13.**—Of this rare metal several ores are here exhibited. The oxide called *Pitchblende* is interesting as being the mineral in which uranium was first detected; whilst the species called *Chalcolite* and *uranite* are attractive by the brilliant colours of their crystals; the former of these minerals contains phosphate of copper, and the latter phosphate of lime, associated in both cases with a phosphate of uranium. Uranium ores are at present worked near Grampound in Cornwall.

Titanium.

Case **13.**—In the state of oxide, titanium occurs in three totally distinct forms, of which specimens are here exhibited. The long prisms of *Rutile* running through the quartz of Perthshire, the fine tabular crystals of *Brookite,* associated with albite-felspar, near Tremadoc, and the small pyramidal crystals of *Anatase,* are simply different forms of the same oxide of titanium; the chemical composition being in all cases identical.

Titanium has been employed for improving the quality of iron and steel, and for the preparation of certain pigments.

Vanadium.

Case **13.**—The vanadate of lead called *Vanadinite,* found not unfrequently in the lead mines of Wanlock Head in Dumfriesshire, will be again noticed among the lead ores (p. 75). Vanadium has been found in the copper-bearing sandstone of Alderley Edge in Cheshire, and appears indeed to enjoy a much wider diffusion than was formerly supposed.

Molybdenum.

Case **13.**—The chief source of this rare metal is the mineral called *Molybdenite,* a sulphide of molybdenum, somewhat resembling plumbago in appearance. Specimens are exhibited from Perthshire, and from the granite rocks of Charnwood Forest in Leicestershire.

Chromium.

Case **13.**—This metal is tolerably abundant in the form of chromate of iron, constituting the mineral called *Chromite* or

chrome iron ore. It usually occurs in serpentinous rocks, and is especially abundant in the serpentine of the Shetland Isles, which has yielded several of the specimens here exhibited. The compounds of chromium are extensively employed in the arts, principally in the preparation of pigments.

Antimony.

Case **14.**—At one period considerable quantities of antimony ore were raised in Cornwall, and some in Dumfriesshire; but none is at present worked in this country. The chief ore is the sulphide, called indifferently *Antimonite*, *stibnite*, and *antimony glance.* By the side of the samples of this ore are a few specimens of *Jamesonite,* a sulphide of antimony and lead, of which enormous lodes occur in Devonshire; but the difficulty of separating the lead and antimony from each other renders them valueless. By the decomposition of jamesonite is produced the yellow antimoniate of lead called *Bleiniere.*

British Gold.

Case **13.**—There is no metal more widely diffused than gold, but it has rarely been found in these islands in sufficient quantities to render the search for it remunerative.

In the tin streams of Cornwall gold has been occasionally found. One fine specimen from Carnon stream is in this collection, and also some of the smaller grains. Gold has also been found in Devonshire, near North Molton, and attempts have been made from time to time to work mines supposed to produce it.

There is abundant evidence to show that the Romans actually worked gold in Wales; and Carmarthenshire and Cardiganshire have at various times yielded the precious metal. During the last few years however, public attention has, been frequently directed to the gold-bearing district of Merionethshire; the excitement which, some years back, attended the workings at the Vigra and Clogau, between Dolgelly and Barmouth, having led to the opening up of numerous other gold mines in adjacent districts, but the operations were in most cases abandoned as unremunerative. The excitement was renewed, however, on the remarkable success which for a while attended the workings at the Morgan Mine, near Dolgelly; but the success was only short lived.

In 1894, the British Gold Fields, formerly the Morgan Mine, raised 5,083 tons of gold ore, of the estimated value of 10,019*l.*; whilst the neighbouring Clogau Mine raised 1,163 tons of ore which was valued at 3,217*l.* The total quantity of gold obtained in Wales during 1894 was 4,235 ounces, of the value of 13,573*l.*

Among the specimens in the case before us are several examples of native gold from Wicklow, the discovery of which

in the last century produced considerable excitement. In 1795 lumps of pure gold were picked up in a valley on the flank of the mountain called Croghan Kinshela; and crowds of the country people quitted their ordinary avocations and rushed to the gold streams. Then a commission directed the operations of streaming, and for a while the works appear to have been remunerative. After suspension for some time, the works were, in 1801, again brought into active operation, and an attempt was made to discover the lodes from which the gold had been derived. The Government, however, were ultimately advised to abandon the works.

Gold has also been found and worked from a very early period in Scotland. Scotch gold is mentioned as early as the year 1125 in a grant made by King David I.; and Pennant says: "In the reign of James IV. and V. of Scotland, vast wealth was procured in the Lead Hills, from the gold found in the sands washed from the mountains; in the reign of the latter not less than to the value of 300,000*l.* sterling." This is evidently a highly exaggerated report. Gold is still found in the Crawford Moor district, and an interesting specimen of auriferous quartz was discovered at Wanlockhead in 1872.

In 1867 public attention was directed to the occurrence of gold in Sutherland, and considerable excitement prevailed during the succeeding two or three years. Large numbers of miners were attracted to the diggings, and in 1868 as much as 577 ounces of gold were returned from Helmsdale; but the yield was not kept up, and the workings were soon abandoned. Several specimens of Sutherland gold are exhibited. Workings have been renewed, but with no marked success, during the present year (1895).

SILVER.

Case **13.**—Silver ores do not occur in any large quanity in this country. True, we obtain annually a large amount of silver from our lead ores, but this will be noticed in a future section (p. 97). *Native silver, silver glance, red silver ore,* and *horn silver* are exhibited from several Cornish mines, but it seems desirable to defer notice of these minerals until the more typical specimens from foreign localities are described (p. 83).

ARSENIC.

Case **13.**—In the lower part of this Case are several specimens of *Mispickel* or *arsenical iron pyrites*, an arsenio-sulphide of iron, frequently found in our western mines, and commonly employed as a source of "white arsenic," the preparation of which will be subsequently described. (*See* p. 96.) Of late years the production of white arsenic has acquired great importance in the west of England, and large quantities are obtained as a by-product in roasting the tin and copper ores. The

quantity of white arsenic produced in Cornwall and Devon during the year 1893 was as much as 5,976 tons, of the value, at the mines, of 57,694*l*.

With this series terminates the first division of the British ores; the remaining section,—including the ores of lead and iron,—being arranged in the recesses on the opposite side of the room to which we now cross.

BRITISH ORES. EASTERN SIDE. *Wall Cases* **43** *to* **56**.

LEAD.

Cases **43**, **44**, **45**.—Lead mining has been carried on in this country from a very early period. When in the possession of the Romans, many of the lead mines in Wales and England were worked, and considerable quantities of lead obtained, as we may infer from the immense accumulation of slags in Derbyshire, the Mendip hills and elsewhere. In the reigns of Henry VIII. and of Queen Elizabeth, especially in the latter reign, an impetus was given to British mining by the introduction of a number of German miners. That mining for lead must, previously to this, have been extensively carried out is proved by the circumstance that Edward the Black Prince took several hundreds of the Derbyshire miners into Devonshire, and it is said that the result of his mining speculations in the west was the realisation of wealth sufficient to defray the expenses of his French wars. Many curious laws were made for, and special privileges were granted to, particular mining districts, as the King's Field in Derbyshire, and the Myne-deeps—as the Mendips were formerly called.

The principal lead-producing counties of England at the present time are Durham, Northumberland, Cumberland, Westmoreland, Yorkshire, Derbyshire, and Shropshire; in Wales Flintshire and Denbighshire; and in Scotland, Lanarkshire and Dumfriesshire. Lead-ore is also raised in large quantities in the Isle of Man. The ores occur mostly in the Carboniferous Limestone, but some in Silurian slates and others in granite.

The most important ore of lead is the widely diffused sulphide called *Galena*. In addition to the lead, of which the purest varieties of galena contain upwards of 86 per cent., various other metals are usually present in greater or less quantity. Of these, silver is the most important, and it is indeed highly probable that neither silver nor gold is ever entirely absent from galena.

Following the specimens of galena are samples of other lead ores, less widely diffused than the sulphide, but many of them, nevertheless, of considerable importance. Foremost among these stands the carbonate of lead, called *Cerussite* or *white lead ore*. This mineral sometimes occurs in acicular or needle-shaped

crystals, of which a magnificent specimen from Devonshire will be found in the central Case No. 31; but more frequently it is found in an earthy form, often investing galena, from whose decomposition it results. Among the oxidized lead ores will also be found some brilliant rhombic crystals of *Anglesite* or sulphate of lead, and of the fine blue mineral called *Linarite*, a sulphate of lead coloured by copper. The phosphate of lead termed *Pyromorphite*, and known to our miners as "green linnets," is a mineral in which the phosphoric acid is frequently replaced to a greater or less extent by arsenic acid, thus passing into the species called *Mimetite*. In these minerals the phosphate and arsenate of lead are associated with plumbic chloride.

The rare vandate of lead, *Vanadinite*, is related by form and composition to the phosphates and arsenates of lead, and these again to the phosphate of lime called apatite.

Iron.

Case **46.**—*Iron pyrites*, although containing nearly one half its weight of metal, is used not so much as a source of iron as of sulphur, and is hence known as *sulphur ore*. In Cornwall, where it is by no means an uncommon constituent of copper veins, it passes under the name of *mundic*, whilst the coal miner, who constantly meets with impure varieties, recognises them as *brasses*.

The name *pyrites* is derived from the Greek (*pur, fire*) because, as Pliny says, "*there was much fire in it.*" Iron pyrites is essentially a bisulphide of iron, and is identical in chemical composition with *Marcasite*, a mineral which, however, crystallises in totally distinct forms; ordinary pyrites appearing in cubes, octahedrons, or certain hemihedral forms derived indirectly from the cube, whilst marcasite occurs in a series of prismatic forms, which have suggested the name of *rhombic pyrites*. It frequently appears in irregularly shaped nodules common in the chalk, and the crystals are often aggregated into groups, forming the variety called "*cockscomb pyrites*."

The arsenical pyrites or *Mispickel* has already been noticed as a source of arsenic (p. 73), and the bronze-coloured magnetic pyrites or *Pyrrhotine* will be mentioned in the description of the foreign ores.

Case **47.**—In this country *Magnetic iron ore* is comparatively unimportant, occurring only in very limited quantity. The peculiar pisolitic ore from Rosedale in Yorkshire is interesting from its occurrence, as a deposit of considerable extent, in the dogger at the base of the Inferior Oolite.

Case **48.**—As the most important of the numerous localities in which the valuable *Hæmatite* or *red iron ore* is found in this country, may be mentioned Ulverstone in North Lancashire, and Whitehaven in West Cumberland. The ore is highly prized for yielding a pig-iron well fitted for conversion into Bessemer

steel. The crystallised variety called *specular ore* or *iron glance* is represented by some specimens from the Cleator Moor deposits, where it occurs in cavities in the compact ore. The delicate scaly crystals from Devon and Anglesey show the characters of the foliated variety of specular iron called *micaceous iron ore* or "shining ore"; whilst the fine reniform and mammillated samples of compact hæmatite from Cumberland and Lancashire exhibit well the characteristic forms which have suggested for these varieties the popular designation of *kidney ore.* On account of the red colour of the powder the name *hæmatite,* from the Greek *haima* (*blood*), is applied to this species.

Case **49.**—A mineral so abundant and so widely diffused as *Limonite* or *brown iron ore* naturally requires an extensive series for its illustration. Among the numerous localities represented in the case before us, the Forest of Dean may be cited as a district in which the brown ores have long been raised. The botryoidal and stalactitic forms, sometimes called *brown hæmatite;* the fibrous varieties, termed from their structure *wood iron ore;* and the friable earthy forms known as yellow and brown *ochres*, are so many varieties of this one species. The composition of these varieties is subject to variation within certain limits; but a crystallised hydrous peroxide of iron of definite composition is occasionally met with, and has been separated as a distinct species under the name of *Göthite.* The magnificent species of göthite from Restormel, near Lostwithiel, in Cornwall, are in every way worthy of notice.

The brown iron ores of the secondary strata, especially those of the lias and the overlying oolites, have acquired, in recent times, considerable importance. Samples of these will be found in the lower part of this Case. The celebrated *Cleveland ironstone,* from the marlstone, or Middle Lias, was discovered in 1848–49, on the north-eastern coast of Yorkshire. The main body of the Cleveland ore is an earthy carbonate of iron, but the upper part of the deposit passes into brown ore. Upwards of four million tons are raised annually.

In Northamptonshire and Lincolnshire, ironstones are now extensively worked and smelted. The *Northamptonshire ironstone* occurs at the base of the Inferior Oolite; while the *Lincolnshire ironstone* is found partly in the Middle and Lower Lias and partly in the Neocomian series. A lias ironstone is also worked near Banbury in Oxfordshire, and an oolitic ore (corallian) at Westbury in Wiltshire.

Case **50**, &c.—Carbonate of iron is known to the mineralogist as *Chalybite* or *siderite,* or as *spathic* or *spathose* ore. In addition to the rhombohedral and lenticular crystals from Cornwall, specimens of spathose ore are shown from the valuable deposits of the Brendon Hills in Somersetshire, and of Weardale in Durham.

Spathose iron ore is a mineral whose composition is subject to considerable variation, the carbonates of lime, magnesia, and protoxide of manganese frequently replacing to a greater or

less extent the carbonate of iron. Moreover this carbonate of iron is frequently associated with impurities which interfere with its crystallisation, and give rise to the dark-coloured massive varieties called *clay-ironstones*. These impure carbonates—which are so profusely distributed throughout our coal-measures, partly as regular seams of variable thickness, and partly as nodular concretions—constitute the ore which, in this country formerly yielded by far the largest amount of our iron —a fact by itself a sufficient apology for the rather large amount of space devoted to the display of these ores, confessedly somewhat unattractive in appearance. But the exhibition of a complete series is the more desirable in an institution of a practical character, since the ores, possessing neither crystalline form nor definite chemical composition, are not entitled to take rank as true mineralogical species, and would therefore find no place in a purely scientific collection.

The extensive series of clay-ironstones commences, with a number of specimens illustrating the characters of the nodular forms, and the minerals which these nodules frequently contain. The lower part of Case **50** and the whole of the six following cases are occupied by the systematic collection of ironstones, arranged geographically in the following order: South Wales, North Wales, Shropshire, South Staffordshire, Warwickshire, North Staffordshire, Yorkshire, Derbyshire, and the Northern Counties.

Intercalated with these argillaceous carbonates of iron are a few samples of the carbonaceous ironstone, well known as *black band*. This ore, which was discovered in 1801 by Mr. Mushet, and is hence frequently called *Mushet stone*, is largely used in the manufacture of Scotch iron.

FOREIGN ORES. *Wall Cases* **15** to **23**.

Copper.

Case **15**.—Among the specimens of *Native copper* which head the series of copper-bearing minerals, attention may be especially directed to the fine samples from the remarkable deposits around Lake Superior. There exists abundant evidence to show that these deposits were worked at a very remote period; and one of the stone hammers used by the primitive miners will be found in Table-case 23. All tradition, however, of these early workings had been lost, and the existence of the metal became known only by the occurrence of masses of copper on the shores of the lake. In 1845 operations were commenced at the Cliff Mine, and these were rapidly followed by other workings. The copper-lands on the south side of the lake consist of Cambrian, or Pre-cambrian (Keweenawan), sandstones and conglomerates, with a

central belt of trap-rocks (diabase) traversed by copper-bearing veins. The metal is also found disseminated through the beds of trap, and through the sandstones and conglomerates; and it likewise occurs in contact deposits between the diabase and the neighbouring rocks. The chief portion of the copper is native. This native copper contains a considerable proportion of silver; but the two metals do not in general occur alloyed with each other, the silver being scattered through the copper in such a manner that each metal remains chemically distinct from the other. (*See* specimens in Case **22.**)

There are also exhibited in this Case specimens of native copper, from the mines of Russia, Tuscany, Cuba, and Chile; whilst of the valuable ore *Cuprite* or *red oxide of copper*, samples are exhibited from several localities in Russia, and from Rhenish Prussia, Hungary, Cuba, and South America. The detached crystals of cuprite from old workings at Chessy, near Lyons, are notable for their large size and perfect form, but the mineral is disguised by a thin coating of green carbonate.

Case **16.**—The greater part of this case is occupied by specimens of the beautiful mineral *Malachite* or *green carbonate of copper*, of which the celebrated Russian deposits have contributed numerous fine examples. The richest masses of malachite have been found about 100 miles south of Bogoslovsk.

Passing from the green to the *blue carbonate of copper*, attention may be invited to the groups of finely-formed brilliant crystals from the now exhausted copper mines of Chessy, about 20 miles N.W. of Lyons: from this famous locality the species has received the name of *Chessylite.* Some magnificent examples of the association of the blue and green carbonates are shown from the copper-mines of Arizona.

The dark blackish-green crystals of *Libethenite*, a hydrous phosphate of copper, and the bright emerald-green *Euchroite*, a hydrous arsenate of copper, both from Libethen in Hungary, are placed by the side of some fine mammillated specimens of the cupreous phosphate called *Ehlite*, and a sample of the rare Russian mineral *Demidovite*, a siliceous phosphate of copper.

The mineral called *Atacamite*, from Atacama, in South America, is an oxychloride of copper occasionally found in sufficient quantity to be worked as an ore, and occurring also as a volcanic product on certain Vesuvian lavas.

In this case are also some fine specimens of *Copper glance* and *bornite* or *purple copper ore*, from the remarkable deposits of Monte Catini in Tuscany. These minerals occur, with other copper ores, in the form of nodules and irregular masses embedded in a steatitic matrix in a dyke of serpentine, or *gabbro verde*, associated with the rock called *gabbro rosso.*

Case **17.**—On the upper shelves of this case are examples of *Copper glance* and *purple ore* from various localities, the fine masses of purple copper from Chile being especially noteworthy.

The important German deposit of *Kupferschiefer*, or copper-slate, is represented by several specimens. This remarkable

stratum lying at the base of the Zechstein, or magnesian limestone, extends uninterruptedly over a very wide area, and in spite of its thinness and its poverty of ore is successfully worked at several points, especially at Mansfeld in Prussian Saxony. Occasionally the cupreous schist contains the fossil remains of Permian fish, and a fine specimen of one of the most common species of *Palæoniscus* is here exhibited. The metallurgical treatment of the Kupferschiefer will be subsequently noticed. (*See* p. 93.)

Iron.

Case **18.**—The series of iron ores commences with several specimens of *Magnetite,* or *magnetic iron ore,* from the hills of Blagodat in the North Ural; but the most interesting samples of this mineral are those from the famous iron mines of Sweden. Some of the best iron is obtained from the Dannemora mines in Upsala Lin, of which large quantities are employed at Sheffield and other places for making steel.

The series of iron ores is interrupted by a small number of *titanium* minerals, among which may be noticed the unusually large crystals of *Rutile* from the United States; the splendid crystals of *Arkansite,* a variety of *Brookite* from Arkansas, United States; and the little square octahedra of *Anatase* from the Grisons. Some fine crystals of *Sphene,* a silicate of calcium and titanium, are also worthy of notice. *Geikielite* is a titanate of magnesium, from Ceylon, recently described by Mr. Dick.

Returning to the iron-producing minerals, we find several shelves occupied by examples of the different varieties of *Hæmatite* or *red iron ore.* Among these the eye will be especially attracted by the brilliant lustre, and in many cases by the iridescent tarnish, of the crystallised variety called *specular iron ore,* of which the Isle of Elba has contributed some beautiful examples. The Elban specular ore, celebrated from remote antiquity, occurs in enormous deposits on the eastern side of the island, where it has long been worked by large open excavations, principally at Rio. Even more brilliant than the Elban specimens are the splendid plates of specular ore from Brazil.

Case **19.**—*Limonite, brown iron ore* or *hydrous peroxide of iron,* occasionally called "*brown hæmatite,*" is a very abundant and widely-diffused mineral, resulting frequently from the decomposition of other iron ores, and often associated with the ores of manganese. The fine stalactitic and botryoidal forms of the Russian specimens, and the fibrous structure of many of the German samples, sufficiently show the characters of the purer varieties; whilst the friable earthy forms passing into ochre are illustrated by examples from various localities. The pure crystallised hydrous per-oxide of iron, of definite composition, has been separated as a distinct species under the name of *Göthite.*

The *bog-iron ore* is an interesting variety of limonite formed in low marshy ground from the decomposition of other iron ores. It always contains a large proportion of impurities, phosphoric acid being often present to a considerable extent. The *lake ores* of Sweden, Norway, and Finland, are concretionary forms of brown iron ore formed, by organic agency, at the bottom of shallow lakes, whence they are obtained by dredging.

Brown iron ore appears in many cases to have resulted from the alteration of the carbonate of iron, to which species we now pass.

This valuable mineral, called indifferently *Spathose iron ore, chalybite, siderite,* and *sparry iron ore,* frequently occurs crystallised in rhombohedral forms, which commonly present curved faces, well seen in the fine specimen from Dauphiné; whilst the large crystals from Hüttenberg in Carinthia exhibit the change of this mineral into brown iron ore by the elimination of carbonic acid and the absorption of oxygen and water. Immense beds of spathose ore are found in Styria, forming part of the Erzberg, a mountain from which it was probably dug by the Romans. In Carinthia an excellent ore of this kind exists, from which iron and steel of the first quality are produced. Valuable deposits of spathose ore occur in the Devonian rocks in the neighbourhood of Siegen in Rhenish Prussia, including the celebrated Stahlberg, near Müsen, where it has been worked since the fourteenth century.

The remainder of this Case is occupied by iron ores of far less importance than those already mentioned. Among these may be noticed the Elban silicate of iron, called *Ilvaite* or *lievrite ;* the common arsenio-sulphide of iron, or *Mispickel ;* and the rarer arsenide of iron, from Reichenstein, termed *Lölingite,* the treatment of which for the separation of gold will be noticed at p. 97. The large pentagonal dodecahedrons of *Iron pyrites* from Elba, and the fine bronze-coloured crystals of *Pyrrhotine* or *magnetic pyrites,* from Brazil, also deserve attention ; and these. with a small collection of *Chrome iron ores,* complete the series.

Manganese, Bismuth, &c.

Case **20.**—Examples of the rarer oxides of manganese called *Hausmannite* and *Braunite* are placed by the side of the oxides known as *Pyrolusite, Manganite,* and *Psilomelane* (p. 70), minerals which are largely raised in Spain, Nassau, Thuringia, and the Hartz. With these oxides are grouped specimens of the pale pink carbonate of manganese called *Diallogite,* or *manganese spar,* and of the rose-red silicate termed *Rhodonite ;* whilst the sulphides are represented by samples of *Alabandine* or *manganese blende,* and by the rare mineral *Hauerite,* from Hungary and Sicily.

The minerals of the somewhat rare metals which follow need but slender description. A few ores of *Bismuth* are introduced, principally from the cobalt mines of Saxony ; and with these are

grouped samples of *Molybdenite* from Bohemia, Greenland, and Chile: these are followed by some Saxon specimens of the uranium-ore called *Pitchblende,* and by the peculiar Swedish mineral known as *Cerite,* in which are associated the silicates of the rare metals, cerium, lanthanium, and didymium.

Tin.

Case **20.**—In the small group of foreign tin ores here intercalated, will be found some fine crystals of tin-stone from Brittany, and several specimens from the tin mines of the Erzgebirge or Ore Mountains, which separate Saxony from Bohemia; and with these are placed samples from Spain, Russia, Greenland, Brazil, and the United States.

Following the tin ores are some specimens of the tungstate of iron and manganese, called *Wolfram,* a mineral with which the ores of tin are commonly associated; and of the tungstate of calcium named *Scheelite,* after the Swedish chemist Scheele.

Cobalt and Nickel.

Case **20.**—The group of cobalt and nickel ores present some interesting specimens, chiefly from the mines of Schneeberg in Saxony and Tunaberg in Sweden. The white cubic crystals of *Smaltine,* with faces frequently curved and fractured; the pale yellow crystals of *Cobaltine,* exhibiting compound forms allied to those of iron pyrites; and the pink crystalline or earthy *Erythrine,* occurring frequently as an incrustation on other ores, are the most prominent among the cobalt minerals; whilst in the group of nickel ores attention may be directed to a small crystallised specimen of *Kupfernickel,* some fine capillary crystals of *Millerite,* a sample of *Breithauptite* or antimonial nickel, and the fine emerald-green incrustations of *Texasite* or *carbonate of nickel* from Pennsylvania. The beautiful green minerals from New Caledonia, known as *Garnierite* and *Noumeite,* are hydrated silicates of nickel and magnesium.

Antimony.

Case **23.**—The series of antimony minerals, placed on the upper shelves, commences with some specimens of the native metal, and of its oxides—*Valentinite* and *Senarmontite.* Of the principal antimony ore, called *Antimony glance* or *stibnite,* numerous specimens are exhibited from various localities; those from Hungary being remarkable for their fine crystalline forms, whilst the Borneo samples are interesting as representatives of a very important locality. It will be observed that some of the specimens are invested with a yellow crust of oxide of antimony, whilst others are coated with the reddish oxysulphide called *Kermesite* or *antimony blende,* of which mineral some specimens are exhibited from Bräunsdorf in Saxony, showing well the characteristic tufts of red hair-like crystals.

Zinc.

Case 21.—On the upper shelves of this Case are some fine examples of the exclusively American ores called *Zincite*, or red oxide of zinc, and *Franklinite*, a mineral in which the zinc oxide is associated with the oxides of iron and manganese, and which is valued as an ore of iron rather than of zinc. The New Jersey specimens are followed by a group of carbonates and silicates of zinc from the celebrated Vieille Montagne or Altenberg deposits. These mines are situated on part of the Belgian, Prussian, and neutral territories, between the towns of Aix-la-Chapelle and Verviers. The calamine of these deposits has been worked since 1435; but for four centuries it was employed merely as an earth wherewith to make brass.

The group of zinc ores is brought to a close by several examples of *Blende*, or sulphide of zinc, of which those from Hungary and Bohemia present fine crystalline forms, whilst other specimens are notable as containing silver.

Lead.

Case 21.—A fuller description of the various minerals from which lead is extracted has been given in the notice of the British series (p. 74): the foreign specimens in the case before us are interesting, however, for comparison with our own.

In the group of lead-spars attention should be directed to the fine transparent and well-formed crystals of *Anglesite*, or sulphate of lead, and of *Cerussite*, or carbonate of lead, from the Wheatley mine in Pennsylvania, where they occur in the upper part of rich lead veins coursing N.E. and S.W. in gneissose rocks Nor must we omit notice of the remarkably brilliant crystals of anglesite which bestud the cavities in the rich galena of Monte Poni, in the island of Sardinia. Of the phosphate of lead called *Pyromorphite* there are exhibited some examples of peculiar hollow crystals from the Wheatley mine, and of fine barrel-shaped crystals from the mines of Nassau. The eye will not fail to be attracted by the brilliant yellow crystals of *Wulfenite* or molybdate of lead, from Utah and Arizona; and here also will be found some sombre specimens of the same species from the lead mines of Carinthia.

A small group of the somewhat rare antimonio-sulphides of lead is here intercalated, including the species called *Boulangerite*, *Plagionite*, and *Geocronite*; and from these we pass to the most widely diffused ore of lead—its sulphide, called *Galena*, of which mineral a large series of specimens is exhibited, fairly representing the principal lead-producing districts of the continent. France, Spain, Tuscany, Saxony, Hungary, and Russia have each contributed samples, and with these European specimens are placed a few lead-ores from certain mines in Asia and America.

SILVER.

Case **22.**—Silver ores have been mined for from the earliest recorded periods of man's history. Throughout Spain, France, and Britain it is quite clear that the Romans eagerly searched for this metal, as they have left behind them numerous remains of their mining and smelting operations. The silver mines of Mexico have been much celebrated since the conquest of that country by Cortes in 1519.

The most productive silver mines in the world have been those of America,—formerly those of Peru and Mexico, and in recent years those of the Western States of North America. The greater part of the silver extracted by mining in Peru is found in a species of ore locally called *pacos ;* it is a brown oxide of iron, with silver disseminated through its mass in exceedingly minute particles. The ore of Chile is similar.

Silver mines of extraordinary value have been developed in recent years in the Western States of North America, especially in Nevada, Colorado, Idaho, Montana, and Utah. Perhaps the most interesting of these discoveries of silver ore are those in Nevada which date from 1859. Workings of enormous value have been opened in the neighbourhood of Virginia City and at other points on the famous Comstock Lode.

Among the silver minerals exhibited in the case before us are some highly interesting specimens of the *native* metal, the fine solid masses from Chile being especially noteworthy. The remarkable association of this metal with native copper in the Lake Superior specimens has already been noticed (p. 78).

Combined with sulphur, either alone or associated with antimony or with arsenic, silver forms a series of beautiful and valuable minerals. Of these the ordinary sulphide called *Argentite, vitreous ore,* or *silver glance,* is a soft and highly malleable mineral, assuming a series of cubic forms closely related to those of galena. Passing over the rare Saxon mineral *Miargyrite,* we may notice among the antimonio-sulphides of silver the beautiful species called *Pyrargyrite, ruby blende,* or *dark red silver ore,* of which the Mexican mines have contributed some magnificent hexagonal crystals; whilst from Saxony is exhibited a specimen of *light red silver ore* or *Proustite,* a mineral chemically differing from the last species in containing arsenic in the place of antimony. To the same class of minerals belong *Stephanite,* or *brittle silver ore,* the rare species called *Fireblende,* and the mineral known as *Polybasite* in which the silver is partially replaced by copper and the antimony by arsenic.

Another group of silver ores is formed by the combination of the metal with chlorine and its allied elements. The chlorides, bromides, and iodides of silver so formed, of which a few specimens are exhibited from the South American mines, are all affected to a greater or less extent by the action of light. It is notable that iodide of silver when heated, instead of expanding, slightly contracts in bulk.

Gold.

Case **23**.—The collection of gold ores is headed by several specimens from Russia. In all probability the auriferous tracts of the Uralian mountains were worked by the Scythians; and the Arimaspi of Herodotus, a people who are fabled to have had but one eye, and to have taken the gold away by violence from the Griffins, may have been, as Humboldt suggests, this nomadic people. Gmelin describes the ancient gold works which he discovered in the district; and Murchison speaks of great piles of ancient drift or gravel which have been removed for the extraction of the gold.

Several specimens have been contributed from the American mines in California, Nevada, Colorado, Alaska, &c. It will be remembered that a large mass of auriferous quartz from the Californian workings is placed in the Hall (No. 162), and described at p. 44. Other specimens are from Mexico, Brazil, Columbia (New Granada), &c.

The long-worked gold mines of Hungary and Transylvania are represented by several specimens.

The "Gold Coast" of West Africa has long been celebrated for its gold, and a nugget brought from Ashantee at the conclusion of the war is here exhibited.

Platinum.

Case **23**.—This metal is obtained principally from detrital deposits in the Ural mountains, especially in the territories of the Demidoff family, and appears to have been derived from the disintegration of serpentine rocks. The largest nugget ever found weighed 21 lbs. troy, and is here represented by a model. For the use of platinum *see* p. 56. An arsenide of platinum, from Canada, has been described as *Sperrylite;* but elsewhere the platinum is found almost exclusively in a native condition. *Osmiridium* is a native alloy of the rare metals iridium and osmium, occurring in association with platinum.

Tellurium.

Case **23**.—The few minerals which contain tellurium occur, in limited quantities, with the gold and antimony ores of Transylvania, and are also found in the Western States of North America (Colorado and California).

The native metal is now exceedingly rare, but at one time it was found in rather large quantities in Transylvania, and was smelted to extract the small quantity of gold which it contains.

In 1782 Müller and Reichenstein showed that the ores of tellurium contained a peculiar metal; Klaproth confirmed this. Sir H. Davy examined some of the oxides, but to Berzelius we are especially indebted for our knowledge of tellurium.

Mercury.

Case **23**.—This metal is occasionally found native in small globules on cinnabar, or in the fissures of the gangue, but the

native metal usually contains a small proportion of silver, the amount of which sometimes rises to a considerable extent, forming the species called *Native Amalgam.* Most of the quicksilver of commerce is, however, obtained from the sulphide known as *Cinnabar* or *native vermilion.* In Europe the most important mines are those of Almaden, near Cordova, in Spain, and of Idria, in Carniola, whilst in California valuable deposits of this ore occur at New Almaden. The metallurgical treatment of cinnabar will be noticed at p. 98.

Arsenic.

Case **23**.—The collection of foreign ores is brought to a close by a few arsenical minerals. Of these the principal are the bright aurora-red bisulphide of arsenic called *Realgar*, and the lemon yellow tersulphide known as *Orpiment*, of which the former is the more important. Both the arsenical sulphides have long been employed as pigments, but for this purpose they are usually prepared artificially.

LODES OR MINERAL VEINS. *Wall Cases* **24** to **36**.

The Wall Cases occupying the circular or north end of this floor are devoted to the exhibition of an instructive series of specimens intended to illustrate, within such a space as may be conveniently studied, many of the conditions under which *lodes* or *mineral veins* occur, and the general characters which they present.

In order to understand these conditions, reference may first be made to the Model of a typical mining district in Cornwall, at present placed in the Model-room A. and numbered I.

The two dissimilar woods are intended to illustrate the prevailing rocks of the country—granite and *killas* or clay slate. The lines which run across these rocks are supposed to represent mineral lodes, containing either tin or copper, as shown by the different colours introduced. Anyone imagining this model to represent some square miles of country, across which there has occurred extensive cracks, either in the process of the consolidation of the rocks, or by mechanical force since the period of consolidation, will realize the facts, in the main, of our mineral-vein formations. Cracks have been formed in the rocks, and these fissures have served as channels for the circulation of subterranean waters, from which mineral matter has been deposited. The exact mode in which the fissures have been filled is, however, a subject of much speculation, but one on which light may be thrown by the study of such a collection of veinstones as is here exhibited. It will be seen that in some cases the minerals must certainly have been deposited from a state of solution, though the source of such solutions may be obscure

The series commences in Case **24** with a number of specimens illustrating the formation of veins on a small scale in nodular concretions of clay-ironstone, by the contraction which the nodules have suffered during consolidation, and the subsequent deposition of various minerals in these fissures of contraction. Not only do carbonate of lime, quartz, hatchettine, and other non-metallic minerals occur in such cracks, but associated with these are found various metalliferous minerals identical with those which form the object of exploration in metallic veins; such for instance, as zinc blende, galena, and copper pyrites. The remainder of this Case is occupied by samples of narrow simple veins known from their small breadth as "strings" or "threads." Some of these branches consist of metallic minerals, others of non-metallic; and some interesting specimens are introduced to show the differences observable in the character of a vein in passing from one rock to another.

The series of simple veins is continued in the succeeding Cases (Nos. **25** and **26**), the veins, however, increasing in width or becoming more powerful. In many specimens introduced into this part of the series it will be observed that the minerals instead of being gathered into strings are distributed through the rocks themselves in an irregular manner; this is especially the case with tin-stone, which frequently occurs disseminated through granite rocks. It has been suggested that in many cases the metalliferous mineral has been segregated or separated from the minerals of the surrounding rocks.

From the simple veins which, with few exceptions, have consisted of a single mineral only, we pass in the next two Cases (**27** and **28**) to illustrations of lodes, consisting, first of two minerals, and then of several. These instructive examples are of high practical value, as illustrating the subject of the "paragenesis" of minerals, or the characteristic association of certain species,—a question of the deepest interest alike to the mineralogist, the geologist, and the miner.

In some instances the formation of the different minerals has evidently been contemporaneous, as in the fine example from the Ecton mines (No. 194), in which calc-spar and copper pyrites have simultaneously crystallised; but in other cases the minerals have obviously been formed in succession, as seen in the fine Brazilian veinstone (No. 203*a*), where we observe a sequence of quartz, dolomite, and magnetic pyrites. The association, however, is in these cases, to a certain extent, irregular, and it remains for us to study in Case **29** those specimens in which may be traced a definite succession of regular deposits. This is strikingly illustrated by the beautiful specimens of "riband" or "banded" veinstone from Saxony (Nos. 232 and 233), in which we notice, within a very limited width, a succession of alternate deposits of quartz, galena, heavy-spar, iron pyrites, and zinc blende, the layers being repeated with tolerable symmetry on each side of the veinstone.

Some interesting specimens in the following Case (**30**) exhibit certain peculiarities in the succession of the deposits. In many of the examples crystals of a later-formed mineral have been deposited on particular sides only of the pre-existing mineral, the cause determining this selective action being in many cases far from obvious.

Vein-deposits after their formation have often been subjected to the action of certain dislocating forces, which have again established fractures, and in these new fissures other minerals have been deposited. Several examples of "comby" lodes are introduced, in which the succession of plates shows that the opening must have been several times repeated at distinct intervals.

The mineral deposited in a vein occasionally serves to cement together angular fragments of the neighbouring rocks, and even of other veins. In Case **31** is a large collection of such *brecciated* lodes, in which a *non-metallic* mineral has acted as the cement; fragments of sandstone, for instance being cemented by heavy-spar; whilst Case **32** is devoted to the exhibition of those in which a *metalliferous* mineral has been introduced as cement, as when sandstone fragments are bound together by galena. In the upper part of Case **33** are some interesting breccias containing fragments of pre-existing lodes; pieces of copper pyrites, for instance, being embedded with fragments of quartz in a "flucan" or clay.

The fine pendent forms of the stalactites, introduced in Case **33**, will naturally attract attention, and it will be observed that many of the Cornish specimens exhibit a regular sequence of deposits, the stalactite having been coated by a succession of newer-deposited minerals.

The polished and striated surfaces of the "slickensides," in Case **34**, evidently point to some sliding or grinding motion in the mass constituting the lode, affording evidence of movement since the formation of the metalliferous matter, such movement as would be sufficient to account for the fissures and breccias to which allusion has been made.

From these evidences of mechanical disturbance in mineral lodes, we may pass to those changes of a chemical character which vein-deposits frequently suffer, as especially attested by the phenomena of *pseudomorphism*. In this case is arranged a large collection of the so-called "displacement" pseudomorphs, or those in which one mineral is deposited either upon or in the place of another. Of such changes the curious "boxes" from Virtuous Lady Mine, near Tavistock, in Devon, are interesting examples: a coating of carbonate of iron has been deposited upon cubic crystals, probably of fluor-spar, and by the subsequent removal of these crystals the encrusting carbonate has been left in the form of large hollow cubes, in which quartz and copper pyrites have finally crystallised. It may thus be readily understood how a cellular character may be imparted to

a lode by the hollows formed on the removal of the original minerals.

In addition to the displacement and substitution-pseudomorphs just noticed, there is yet a third group in which the change of mineral is readily explicable by chemical action, and of these "alteration"-pseudomorphs a series is exhibited in the succeeding Case (**35**). These may result either from the addition or from the removal of a constituent, or from a partial exchange of ingredients. Thus the crystal of calamine in the form of a large scalenohedron of calcite has been formed by the exchange of lime for oxide of zinc. So obvious in many cases is the formation of these "epigenic" pseudomorphs that it may be, to a certain extent, successfully imitated, and an interesting series of such artificial pseudomorphs, prepared by Dr. Sorby, F.R.S,, is placed in this Case. In nature, such chemical action occurs in many cases on a very extended scale, affecting mineral masses often of enormous extent. To illustrate such changes there is introduced into this Case a large series of minerals occurring mostly in the upper part of lodes, where the original deposits have been subjected to atmospheric influences. Thus the crystals of anglesite often found in the shallow workings of a lead vein are true products of alteration, having resulted from the absorption of oxygen by the galena forming the body of the lode, and the consequent oxidation of the sulphide of lead to a sulphate. A common alteration in veins is that in which iron pyrites is superficially converted into brown iron ore, by elimination of sulphur and addition of oxygen and water. On the "back" or outcrop of a lode such a change is exceedingly common, the superficial deposit of loose brown iron ore, which thus acts as a cap to the ore beneath, passing under the name of "*gossan*." The greater part of the following Case (**36**) is devoted to the display of varied samples of this gossan, which, although not perhaps very attractive to the eye, are nevertheless of the highest importance to the miner, who is frequently enabled to judge from them of the probability of cutting ore in the deeper workings. (For pseudomorphs, *see also* p. 55.)

The remaining portion of this Case (**36**) is occupied by a collection of specimens illustrating certain chemical changes in metallic minerals, resulting in the production of native metals: thus there will be found, among the specimens, crystals having the characteristic octahedral form of red oxide of copper, but consisting entirely of the native metal; the copper having been reduced from its combination with oxygen; and it is indeed probable that many of the metals which now occur in a native state have been reduced by successive stages from various combinations, often of considerable complexity.

In connexion with the veinstones, the visitor may study a series of specimens recently placed in the Model Room A. (Case IV.) intended to illustrate the various modes in which metalliferous minerals occur in nature.

COLONIAL PRODUCTIONS.

Wall Cases **37** *to* **42** *on E. side.*

AUSTRALASIA.

Case **37.**—Passing over a few specimens from New Zealand, placed on the upper shelves, we find the greater part of this Case devoted to the *copper-ores* of Australia. Here the eye is attracted by the fine masses of the green and blue carbonates of copper, known respectively as malachite and azurite, and by the brilliant dark-green crystals of atacamite, or oxychloride of copper. The carbonates are principally from the once-famous mines of Burra Burra, situated about 90 miles N.E. of Adelaide. The rich deposits of carbonate of copper in the earlier workings at these mines resembled in many respects the malachite formations of Russia, already described. The Burra Burra mines were started on the 5th September 1845, and in spite of the rudeness of the early workings, their distance from the shipping port, and the disadvantage of unmade roads, they yielded during the first five years a profit of nearly half a million sterling. In Case 21 (p. 65), are some fine specimens of the red oxide and blue and green carbonates from the same mines; and in the Lower Hall is another large mass of the ore (No. 89). The discovery of copper-ore at Wallaroo, on Yorke peninsula, in South Australia, was made by a shepherd in 1860, and the Wallaroo mines were at once started. Another discovery was soon afterwards made about 10 miles south of Wallaroo, which resulted in the formation of the celebrated Moonta mines.

Case **38.**—The series of Australian copper ores is continued in the upper part of this Case, and is followed by samples of the ores of iron, lead, antimony, &c. *Stream-tin* was found long ago in association with alluvial gold in the "black sand" of Victoria; but the Victorian deposits have yielded in importance to those of New South Wales and Queensland. Here the ore occurs not only as detrital tin-stone, in the beds of many streams and in alluvial flats, but also in veins or lodes coursing through granitic rocks. A large series of Australian tin-ores, including some fine samples from Vegetable Creek in New South Wales, will be found in this Case; whilst in the lower part of Case **37** are some larger masses of tin ore illustrating the important occurrence of this mineral at Mount Bischoff in Tasmania. Specimens of many of the *precious stones* found in the alluvial deposits of New South Wales are exhibited in Case **38,** including a series from the Bingera diamond fields, presented (with many others) by Prof. Liversidge, F.R.S., of Sydney. An interesting suite of specimens, from the remarkable mines at Broken Hills, in New South Wales, shows the occurrence of *silver* in the form of chloro-bromide and iodide; whilst a small group of specimens on one of the lower shelves illustrates the occurrence of *gold* in a rather exceptional form at the famous Mount Morgan in

Queensland. The gold deposits of Western Australia are also represented in this Case. The principal specimens of Australian gold, however, are exhibited in a special Case, No. 23, noticed at p. 51; and an attractive model, explaining the method of gold-mining in Victoria, will be found in the Model Room (p. 135).

East Indies.

Case **39.**—This Case is devoted to the display of Indian minerals, but the Indian series commences with a few specimens in Case **38,** and is continued in Case **40.** The metalliferous minerals include samples of the ores of iron, manganese, cobalt, copper, and antimony; but these are of subordinate interest to the collection of *gold-ores* from Mysore and the Wynaad. The large series of *ochres,* used as pigments, from the Madras Presidency, is followed by an extensive collection of varieties of corundum. The name of *corundum* is applied to the opaque, roughly crystallised kinds of native alumina, whilst the massive and more impure forms of the same species are known as *emery;* the passage of corundum into emery is illustrated in this series. From its hardness, which is inferior only to that of the diamond, the mineral in its coarser forms is extensively used for grinding and polishing purposes (p. 39). Some samples of *graphite,* or plumbago, from Ceylon, are also placed in this Case, but the mineral is better represented by specimens in the central Horseshoe Case (p. 103).

Case **40.**—The non-metallic minerals of India extend into this Case, where the upper shelves are devoted to a series of specimens of *rock salt, nitre,* &c. Then follows a collection of *tin-ores* from Perak and Johore, in the Malay Peninsula, and from the islands of Banca and Billiton. A fine mass of tin-ore from Selangor is placed on the bottom shelf. So important are the tin workings in this part of the world that the tin and tin-ore imported into the United Kingdom from the Straits Settlements during the year 1893 was estimated to have the value of nearly two millions and a quarter sterling.

A small group of specimens, principally from Jamaica, illustrating the resources of the *West Indies* is intercalated between the minerals of the East Indies and those of British America.

British America.

Case **40.**—The mineral wealth of Canada is very fairly represented in this Case and the following one. The series commences with a suite of specimens of *asbestos,* a mineral which in recent years has been rather largely worked in the serpentine rocks of certain parts of Canada, and which receives extensive application in the arts, as is well shown by the technological series in the Horseshoe Case (p. 117). Then follow some fine examples of the *apatite,* or phosphate of lime, which occurs in considerable deposits in the Laurentian limestones, and is valued

for conversion into superphosphate, to be used as a fertilising agent. Other examples of Canadian apatite are placed with the phosphates, and elsewhere in the Museum (pp. 43, 110, 138).

Interest naturally attaches to the Canadian iron ores, of which large samples will be found on the floor of this case and that of the next. The *bog ore* has a very wide superficial distribution, and the richer *magnetic ore* occurs in beds of prodigious extent, while the *titaniferous iron ore*, from its occurrence in large quantity, promises to become of importance. From Eastern Canada are obtained the *chrome iron ores*, which, as usual, are associated with serpentine rocks.

Case **41.**—On the top shelves of this Case are samples of Canadian *plumbago*, or graphite, and some plates of *mica*, exceptional in size and thickness. These are followed by specimens of various ores, including those of copper, cobalt, nickel, antimony, silver, &c. The nickeliferous pyrrhotite, or magnetic pyrites, of Sudbury, Ontario, has been extensively worked as a source of nickel.

A prominent position in the Case before us is given to the collection illustrating the gold districts of British America. It appears that as early as 1852 small quantities of gold were found in Queen Charlotte Island, and the metal was afterwards discovered on the mainland, in the Frazer River valley, and in various parts of the Cascade range. The first official report of these discoveries, which was received in 1856 from the Governor of Vancouver Island, failed to excite any considerable attention; but the extent of the deposits and the success of the operations which were in progress being confirmed by subsequent reports, public attention was at length aroused, and in 1858 vast numbers of emigrants flocked to the new colony. The great centre of the most successful workings was the rich auriferous district situated some distance inland, and known (from being a favourite haunt of the reindeer or *cariboeuf*) as the Cariboo country. The beds of the Frazer River and its numerous tributaries were also highly productive, and the alluvial terraces which border many of the streams yielded much gold to the "bench diggers." A nugget of gold weighing 7 ozs. 13 dwts., from the Thompson River, British Columbia, is here exhibited.

Before leaving this Case attention should be drawn to the specimens of gold, and models of nuggets, from the Gilbert River in Lower Canada. From Nova Scotia are exhibited some samples of the so-called "barrel-quartz" of Laidlaw. Occurring beneath only a few feet of quartzose rock, it forms an extensive horizontal bed, presenting a remarkable succession of folds or contortions, and the undulating surface of the deposit has suggested the local name.

South Africa.

Case **42.**—It has been found convenient to group together in this Case all the minerals from South Africa, whether from

British territory or not. A large collection of *copper-ores* and other minerals from Namaqualand occupies the upper part of the Case. But the visitor will probably turn from these to the series of specimens illustrating the extraordinary occurrence of *gold* in the Transvaal. Many of the important mines of the Witwatersrand are here represented, and several specimens show distinctly the character of the stratified deposits in which the gold occurs. The famous "banket" is a conglomerate of quartz pebbles, united by a siliceous cement, containing more or less gold. Large specimens of free gold are not common, but some masses of exceptional character are here exhibited.

In the lower part of the Case are specimens of the beautiful fibrous material known, when cut and polished, as "South African Cat's-eye." This is a mineral representing fibrous *crocidolite*, but consisting in its present form essentially of quartz with oxide of iron. The bottom shelves are occupied with a series of specimens illustrating the occurrence of *diamonds* in the famous fields of Kimberley. The diamonds occur in an altered serpentinous matrix occupying pipes, believed to represent volcanic vents which have burst through the shales and sheets of eruptive rock in the Karoo formation (p. 102).

THE METALLURGICAL COLLECTIONS.

In the recesses on each side of the room, at the southern or Jermyn Street end, the visitor will find six flat cases which are devoted exclusively to the illustration of metallurgical operations. These cases are placed, as far as convenient, in front of the wall-cases containing the corresponding ores whose metallurgical treatment is here illustrated; the series of iron-smelting products, for example, being arranged immediately in front of the British iron ores. The processes illustrated in these Cases, although for the most part British, are by no means exclusively so; specimens from foreign works being, in many instances, placed by the side of our own productions for purposes of comparison and illustration.

COPPER-SMELTING.

Table Case 40.—The ore when raised from the mine may be mixed with other metallic minerals or with earthy substances, and it has, therefore, as a first operation, to be freed as much as possible from these by a process of *dressing*. In the boxes in this Case are shown the ores in their various stages of preparation until they pass into the hands of the smelter.

The process of copper-smelting, as conducted about the year 1840, at Messrs. Vivian's works at Swansea, in South Wales, is here fully illustrated. The dressed ore having been calcined in a reverberatory furnace was fused to the condition of *coarse metal*, which after calcination, was melted with certain

oxidised copper ores and slags; and the *white metal*, or *pimple-metal*, resulting from this fusion yielded, on roasting, a crude variety of copper, called *blister copper*, which was subsequently refined by exposure to oxidising influences in a reverberatory furnace. During these operations the sulphide of iron in the ore was converted into an oxide, which, combining with the siliceous matters present, formed a fusible *slag;* and the iron being thus removed, the sulphide of copper suffered decomposition, its sulphur being evolved as sulphurous acid, whilst the oxide of copper (cuprous oxide), formed during refining, was reduced in the final operation of *toughening*. The Welsh process, more or less modified, is still extensively employed.

In the process of toughening, the surface of the copper is well covered with anthracite, and a *pole*, usually of green birch, is held in the liquid metal, the evolution of gaseous matter causing considerable ebullition. This operation of *poling* is continued until the metal is found to be in the best condition. The operation requires great care; both *under poling* and *over poling* being found injurious. Some specimens in this case illustrate Mr. Weston's process of refining copper by addition of a compound of copper and phosphorus.

Copper passes into the market in the conditions of *cake* (ingot) and *sheet* copper of various descriptions. Granulation may be effected by pouring the metal in a molten state into a vessel pierced with holes, supported over a cistern of water. When it falls into hot water the copper assumes a rounded form, and is called *bean shot*, and when into cold water, from its assuming a ragged appearance, it is called *feathered shot*. Copper is also cast, chiefly for exportation to the East Indies, in pieces of the length of six inches, and weighing about eight ounces each; these are called *Japan copper*.

Table Case 38.—In this Case are exhibited some specimens illustrating certain Continental processes of copper smelting.

The treatment of the remarkable *Kupferschiefer* or copper-slate (p. 78) is here illustrated. This schist, which is extensively smelted in the neighbourhood of Mansfeld, in Prussian Saxony, contains on an average not more than three or four per cent. of copper, with a small proportion of silver, about 10lbs. to the ton of copper. After calcination for a considerable time in large heaps, the ore is mixed with a certain amount of slag and flux in the form of fluor-spar, and the mixture smelted in a blast furnace; the product being subjected to successive roastings, until at length a concentrated regulus is obtained from which the silver is extracted, and the copper-bearing residuum subsequently smelted. At the time this series was obtained the silver was extracted by Augustin's method, which is accordingly here illustrated, but at present a different process is adopted. Examples of the *rosette copper* formerly made at Mansfeld are here shown. A little water was thrown on to the bath of molten copper, in a hemispherical basin, in order to determine the

solidification of the superficial crust, which was then removed in the form of a thin circular plate or *rosette;* more water was then thrown on the fused mass, and other discs were successively obtained, until the whole of the charge had been removed.

By the side of the German specimens is a small group illustrating the process of Copper smelting at Falun, in Dalecarlia, Sweden.

Tin-Smelting.

Table Case 38.—In this Case will be found some ancient blocks of Cornish tin, known as *Jews' tin,* while the rude furnaces, which are not unfrequently discovered in connexion with them, are termed *Jews'* houses. This arises from the fact that during the reign of John, and subsequently, the tin mines of Cornwall were farmed by the Jews. Those blocks, and the furnaces named, are, however, probably very much older than this period. A model of a remarkable block of tin, which was fished up from off St. Mawes, at the mouth of Falmouth harbour, will also be found in Case **10.** The original block is in the Museum of the Royal Institution of Cornwall, at Truro. The late Sir Henry James showed, with much ingenuity, that the form of this block was peculiarly adapted for its transport, both by land and water.

Tin smelting is a simple operation, conducted either in the reverberatory furnace, or in the blast furnace: in Cornwall the former method is now always employed. The tin ore, having been roasted and washed, is mixed with small anthracite or culm; and a small quantity of either slaked lime or fluorspar, which serves as a flux for its siliceous impurities, is mixed with it previously to its being placed in the furnace and smelted. The crude tin is refined by *liquation,* or sweating, in a reverberatory furnace, and the resulting product is then generally *poled,* or stirred with green wood.

During more than six centuries the tin paid a tax to the Earls and Dukes of Cornwall. The blocks of tin were subjected to a process called "coining," and certain towns were fixed upon as *coinage towns.* The blocks of tin—rectangular masses—weighing about 3·34 cwts. each, were sent to the *coinage Hall;* a corner of each of the blocks was struck off, and some of the *Coinage pieces* are in this Case: these were examined by Duchy officers appointed for the purpose, in order to see that the tin was of proper quality; the blocks were then stamped with the Duchy seal, the dues paid, and the blocks permitted to be sold. By an Act of Parliament of 1838, the duties payable on the coinage of tin in Devon and Cornwall were abolished.

The finer varieties of tin, known as *grain tin,* which are used principally by the dyers, are usually prepared by heating blocks of tin to a certain temperature, and then breaking them by a blow from a heavy hammer, or by a fall from a small height.

Oxland's process for separating wolfram from tin is illustrated in this Case. The wolfram is a tungstate of iron and manganese, and by calcining the ore with carbonate of soda, a tungstate of soda is produced, and this being a soluble salt is readily removed by water.

Zinc-Smelting.

Table Case 33.—Agricola, and others in his age, regarded calamine as an earth containing no metal, although it had long been employed in the manufacture of brass. Van Swab in 1742, and Magraf in 1746, separated zinc from calamine by distillation in close vessels. Pott, in 1741, wrote a dissertation on zinc, in which he speaks of it as a semi-metal. The name zinc first occurs in the works of Theophrastus Paracelsus.

The zinc ore, whether calamine or blende, is first roasted, and the oxide thus obtained reduced by smelting with carbonaceous matter. In this country the reduction was formerly effected in a crucible, provided at the bottom with a tube, through which the zinc vapour descended.

The celebrated Vieille Montagne ores have been noticed at p. 82. The Abbé Dony first established the smelting works, which passed into the hands of the Mosselman family in 1818, and in 1837 into the possession of the present proprietors, the Vieille Montagne Zinc Company. The distillation is conducted in a series of clay retorts, furnished with cast-iron conical condensers.

The extraction of zinc and preparation of the oxide of zinc, or *zinc white*, as conducted by the Lehigh Zinc Company at Bethlehem, Pennsylvania, is well illustrated by a large suite of specimens presented by the company, and exhibited in the Case before us. Zinc white is largely employed as a pigment in the place of white lead, over which it has the advantage of being less poisonous, and of not blackening on exposure to sulphuretted hydrogen.

Brass.

Table Case 33.—In the arrangement of these Table Cases we have first the simple metals, copper, tin, and zinc; then the alloy of copper and tin, forming *bronze;* and finally that of copper and zinc, forming *brass.*

For the production of differently coloured brasses, and to meet the required conditions of various manufacturing processes, the proportions of copper and zinc in brass are infinitely varied. A common proportion is 2 parts of copper to 1 of zinc. Formerly brass was manufactured by heating in crucibles a mixture of granulated copper, calcined calamine (carbonate of zinc), and ground coal. At the present day, however, the alloy is prepared directly by fusing together the proper proportions of copper and zinc either in crucibles or in a reverberatory furnace.

Nickel and German Silver.

Table Case 33.—The metallurgy of nickel is usually kept a secret by the manufacturers. In Case 18 will be found some specimens illustrating the extraction of nickel in Sweden. Of late years nickel has been prepared on a large scale from the rich silicate ores of New Caledonia, and from the nickeliferous pyrrhotite of Sudbury, Ontario, in Canada.

The metal is produced in large quantities to meet the demands of the makers of German silver. Several white metals, bearing different names, such as nickel silver, albata plate, &c., are only varieties of German silver.

Smalts and other Cobalt Colours.

Table Case 33.—The preparation of the beautiful cobalt-blues was discovered in Saxony about 1540, and it has since that time been carried on extensively in that country. The cobalt in the ores is converted into oxide by roasting, and the oxide of cobalt thus produced is vitrified, with the addition of pure potash and silica. The product called *smalt* is really a double silicate of cobalt and potash. Smalt is, therefore, simply a cobalt glass; this ground to fine powder and carefully washed is applicable to all purposes in which a cheap and durable blue is required as a paint, and for giving a blue tint to paper or linen. For colouring earthenware the roasted ore, with an addition of powdered flint and nitre, is sent into the market under the name of *Zaffre* or *Saflor* (a corruption from sapphire); and the colour required is developed in the process of firing the glazed ware. In this case will be found a large series of the colours produced by chemical treatment from cobalt. Whilst the silicate of cobalt and potash forms *smalt* and *cobalt* or *Licknor's blue;* oxide of cobalt and oxide of zinc form *Rinman's green;* and phosphate of cobalt with alumina, *Thenard's blue:* arsenite of cobalt produces a *purple,* and silicate of cobalt a *pink,* colour.

Arsenic, &c.

Table Case 33.—Arsenic is employed in commerce mainly in the form of *white arsenic* or *arsenious oxide.* Large quantities of this oxide are now prepared in Devon and Cornwall by roasting ores of copper and tin. In 1894 the production amounted to 4,754 tons, and the previous year it reached 5,976 tons. The arsenic exists in the ore as mispickel or "arsenical mundic"—a compound of arsenic, sulphur, and iron (p. 73).

The ores are placed on the hearth of a reverberatory furnace, through which a current of air is allowed to play. The sulphur present is converted into sulphurous acid gas, while the arsenic volatilises as an oxide, which is readily condensed in the flues. To obtain pure arsenious oxide the first products thus directly obtained are subjected to a second sublimation.

Plattner's method of *gold extraction* by means of chlorine, as formerly used at Reichenstein, in Silesia, for the treatment of residues of arsenical ores (lölingite) containing about $1\frac{1}{4}$ ounces of gold to the ton, and about 5 per cent. of arsenic, is illustrated in this Case. Chlorination processes are still largely employed for gold extraction. Of late years, too, a dilute solution of cyanide of potassium has been very extensively used for obtaining gold from the "tailings" of the gold mills.

The preparation of many of the other less common metals, and their compounds, such as antimony, bismuth, cadmium, aluminium, &c., receives illustration in the Pedestal Case No. 35, immediately opposite to the Table Case under description (*see* p. 56).

The remaining Table Cases of the metallurgical series stand in the three embayments on the opposite side of the room, to which therefore we now cross.

Lead-Smelting.

Table Case 17.—The processes of smelting lead and of separating the silver from it were known at a very early period. The Book of Job clearly describes the metallurgical and mining processes; and in Jeremiah we read, "the bellows are burned, the lead is consumed of the fire; the founder melteth in vain. . . Reprobate silver shall men call them." This passage proves the knowledge of the processes of desilverising lead by oxidation, such as, until of late years, has been commonly employed. The traces of old Roman lead mines are very extensive in many parts of Europe, and the discovery of Roman pigs of lead by no means uncommon. These were usually stamped with the name of the emperor under whose reign the lead had been produced. One of these Roman pigs of lead will be found in the collection, and two casts from other pigs. The original pig was one of fifty found in an old smelting work discovered near Orihuela, Valencia, Spain (*see* Wall Case 44).

Metallic lead is obtained either by simply roasting the galena, or native sulphide, under proper conditions; or by roasting the ore, and then reducing the oxidised products by means of carbonaceous matters; or finally by removing the sulphur from galena by heating it with metallic iron. The operations of lead smelting may be conducted either in reverberatory furnaces, in blast-furnaces, or on shallow hearths.

The process of desilverising lead was formerly effected by oxidising the lead, the oxide being from time to time removed from the furnace, leaving the silver upon the bed of bone ashes prepared to receive it. A vast improvement was effected by the late Mr. Hugh Lee Pattinson, who discovered that lead consolidated, or crystallised, at a higher temperature than the alloy of lead and silver; consequently that, if he kept lead containing silver in a state of fusion at the lowest temperature at which the fluid state could be maintained, solid masses were gradually formed, which were found to be almost pure lead Thus

a large portion of lead in a state of comparative purity is removed, and the fluid portion which remains at the last is exceedingly rich in silver. This enriched lead is subjected to the oxidising process, or *cupellation*, and the silver separated.

While the old process was in use, if the lead contained less than eight ounces of silver to the ton, it was not found profitable to separate it, but by Pattinson's process it is profitable when it does not contain more than three ounces to the ton. Beyond this, more silver is now obtained from the lead than formerly.

In many places the Pattinsonisation process has now been displaced by a process of "zincing," whereby the lead is desilverised by means of zinc, as originally suggested by Mr. Alexander Parkes, of Birmingham.

An interesting series of specimens is exhibited to illustrate Mr. Baker's process of softening hard lead, patented in 1860.

A small group of specimens illustrating one of the processes employed for the manufacture of *white lead* is also here introduced. Metallic lead, cast into the form of gratings, is exposed to the action of the vapour of vinegar in beds of fermenting tan. The basic acetate of lead first formed is decomposed by the carbonic acid present, and in this way is obtained a carbonate of lead, which, when purified by washing and levigation is ready for use as a pigment. When white lead is roasted it suffers decomposition, and the residuum, consisting of oxide of lead with a little carbonate, is employed under the name of *orange lead*. *Litharge* is obtained by oxidising lead in a reverberatory furnace, and the product when further roasted forms the higher oxide known as *red lead*.

Amalgamation of Silver Ores.

Table Case 17.—The process of the amalgamation of silver ores as formerly practised at Halsbrücke, near Freiberg in Saxony, is illustrated by a complete series of specimens. The process consisted essentially in roasting the ore with common salt; the main result being the conversion of the sulphide of silver into chloride of silver. This was mixed with mercury and fragments of wrought iron, and placed in revolving casks, the mass being kept in motion for about 20 hours, when the amalgamation was complete.

Mercury.

Table Case 17.—Some mercurial ores from Idria in Austria, and from Hungary, are here associated with the metallic mercury and the vermilion prepared from them. The ore from Idria is principally bituminous cinnabar associated with native mercury. On submitting the ore to distillation the sulphur is expelled, whilst the mercury, or quicksilver, is volatilised and collected in a series of condensing chambers.

When mercury is rubbed with sulphur in a mortar the black sulphide, *Ethiop's mineral*, is produced. If this powder be

heated to redness it sublimes, and if a proper vessel be placed to receive the sublimed substance, a cake of fine red colour is obtained, called *cinnabar;* this being reduced to powder forms the *vermilion* of commerce.

Iron and Steel Manufacture.

Table Cases 9 *and* 11.—In well-marked divisions in Case 9 the results of the processes of smelting the ores of iron are shown from the following iron works:—

Whitehaven Iron Works	Cumberland.
Low Moor ditto	Yorkshire.
Bowling ditto	Yorkshire.
Farnley ditto	Yorkshire.
Russell's Hall ditto	South Staffordshire.
Plymouth ditto	Glamorganshire.
Dowlais ditto	Glamorganshire.
Maesteg ditto	Glamorganshire.
Monkland ditto	Lanarkshire.

The iron ore, or "mine," if in the state of carbonate, is first calcined, either in open heaps, or more usually in kilns. By calcination, carbonic acid gas, water and other volatile ingredients are expelled. The smelting of the ore, whether raw or calcined, is effected in the blast furnace. The furnace which is now often made of very large size, is charged with ore, fuel, and flux. The flux is usually limestone, which yields lime to combine with the silica of the ore, thus forming a fusible double silicate of lime and alumina, which appears as a *slag;* while the iron is separated and collected in a fluid state at the bottom of the furnace, from which it flows out at the proper time and is collected in sand moulds prepared for it, producing the masses known by the name of *pigs.*

As an intense heat is required for smelting iron ores, a strong blast of air is constantly injected through *twyers.* By employing heated air a saving is effected in the process of smelting, and it is now common to make the air traverse pipes which are heated in a stove before it enters the blast furnace. Iron prepared by the hot-air process is called *hot blast iron,* but when the air is admitted to the blast furnace cold it is known as *cold blast.*

The crude metal obtained from the blast furnace is termed *cast-iron,* of which there are three leading varieties, known as grey, mottled and white cast-iron.

All these varieties contain a considerable amount of carbon, sometimes as much as five per cent., together with small quantities of silica, sulphur, phosphorus, &c. These impurities are oxidized during the conversion of the cast-iron into *wrought* or *malleable iron.* This is usually effected in a reverberatory furnace, where the metal is exposed to a current of air and

frequently stirred or rabbled. The operation is called *puddling*, and instead of relying entirely on the action of the air to remove the excess of carbon, a variable proportion of the oxide of iron or of maganese is commonly employed. As the carbon passes off as carbonic oxide the iron becomes less fusible, and ultimately breaks up into an incoherent granular mass like sand. The heat is then increased, the grains agglutinate, and being worked up into a ball, the mass is taken from the furnace and subjected to great pressure by machinery. The lump of malleable iron thus obtained is then passed through a succession of rollers, turned by a powerful steam engine, each pair of rollers having a smaller interval than the preceding; by this means the mass is gradually elongated into a bar, and at the end of the rollers furthest from the furnace it passes out as the soft bar iron of commerce. Some fine examples of such iron will be found in the entrance hall.

Whilst pig-iron is always brittle and exhibits a more or less crystalline structure, the puddled iron, after being duly hammered and rolled, is extremely malleable and presents on fracture a decidedly fibrous texture. Some specimens in Case 51 are interesting as illustrating a *supposed alteration in the structure of wrought iron by vibration.*

A *railway axle* bent by an accident without breaking will be found in the Model Room A.

STEEL MANUFACTURE. *Table Case* 11.—Steel may be regarded, in its typical form, as representing a condition intermediate between cast iron and wrought iron. The proportion of carbon which is present varies considerably in different varieties; mild steel may not contain more than 0·2 per cent., or, when very soft, even less, whilst the harder tempers may contain ten times as much, or nearly 2 per cent.

Steel is sometimes formed directly from the ore, as in the Catalan forge; more frequently it is obtained by adding carbon to malleable iron, as in the old process of cementation; whilst often again it is produced by the decarbonization of pig-iron, as in the Bessemer process, and in the basic process of Messrs. Thomas and Gilchrist; or, finally, it may be obtained by the addition of oxidised iron ores, or of a malleable iron to pig-iron in an open hearth, as in the Siemens and Siemens-Martin processes. The old *cementatian method* of steel making is here illustrated by a series of specimens from Sheffield.

Blister Steel probably owes its warty surface to the formation within the mass of a gaseous compound of carbon and oxygen, which occasions the formation of bubbles in the metal.

The *shear steel* is made from blistered bars, by cutting them into lengths, fagotting several together, re-heating and welding the pile, and then hammering or rolling it into rods.

In making the *cast steel*, shown here, blister bars are broken into small pieces and fused in a barrel-shaped crucible of Stourbridge clay, and the molten steel is then poured into a mould.

Steel is commonly *hardened* by being plunged, when red hot, into water; and it is afterwards *tempered* by being re-heated until the surface assumes a tinge varying from a light straw colour to a deep blue. An interesting series of polished *specimens of steel at the different colours for tempering* will be found in this Case. The tints appear to be due to extremely thin oxidised films.

Attention should also be called to a series illustrating the production of steel and malleable iron from fusion of pig-iron and hæmatite by *Clay's process.* There will also be found here several examples of *Mushet's tool steel,* and numerous fragments of steel *shot* and *armour plates.* In connexion with steel manufacture it should be remarked that somes fine examples of *Bessemer steel* will be found in the lower compartment of Pedestal-case No. 13. A sample of *Whitworth steel,* cast under pressure to ensure soundness in the ingot, and a specimen of *Siemens' steel* will also be found here.

The metallurgical series, though far from complete, has outgrown the six table-cases to which it was formerly restricted, and it has been found necessary to devote several cases in the Central Area to this department of the collection. It is, however, needless to allude further to these cases, since they have already received brief notice at pp. 61, 63.

HORSESHOE CASE.

"Non-Metallic" Minerals and their Applications.

Formerly the collection of non-metallic minerals was confined to a large glass case, of horseshoe form, running round a similarly-shaped space in the centre of the room, which admits light to the Lecture Theatre situated below. Many years ago, however, it was found necessary to extend this case by adding others, which are supported on the cornice of the balustrade surrounding the opening from the Principal Floor to the Lower Hall. The case is divided into 28 compartments or separate sections, each equivalent to an independent case. The 28 cases form a closed series, somewhat D-shaped; but though the collection has thus lost its horseshoe form, its original name is still conveniently retained.

In the Horseshoe Case the visitor will find all the gems and ornamental stones, the spars, and earthy minerals. These are grouped together under the general term of "non-metallic," in conformity with popular usage and practical convenience; but visitors will bear in mind that whilst many of the species here exhibited, such as the diamond, are strictly destitute of metal, by far the larger number contain some metallic element, principally, however, the rarer metals of low density, such as potassium and aluminium, and but rarely the common heavy metals of commerce.

Each case, or separate compartment of the Horseshoe Case, will be briefly described, commencing at the south-east corner of the series.

Case A.—Diamond.

From the high refracting power of the diamond, Sir Isaac Newton conjectured that this beautiful gem might be an unctuous body, and therefore combustible. Heated in oxygen gas, the diamond may readily be burned, producing only carbon dioxide, and leaving a small quantity of ash, whilst in the electric arc it has been converted into a coke-like mass, thus proving it to be only a peculiar form of carbon.

Diamonds are found naturally crystallised, the forms always being related to the cube and the faces being often rounded, as seen in many of the crystals exhibited. Diamonds were discovered at a very early period in the East Indies, and most of the large historical diamonds were obtained from India, especially from the so-called Golconda mines. Early in the last century diamonds were discovered in Brazil, where they occur chiefly in a deposit called *cascalho*, consisting principally of fragments of quartz and ferruginous sand: a sample of this cascalho is shown. Both India and Brazil have, however, been overshadowed by the discovery of diamonds in unparalled abundance in South Africa. The first diamond was found in the Colesberg district in 1867, and was sold for 500*l.*; a model of this stone is exhibited. Large numbers of diggers were soon attracted to the fields, and their labours rewarded by the discovery of vast numbers of diamonds, including many of unusual size.

The "river-diggings," established at first in the gravels of the Vaal River, were soon abandoned for the "dry diggings," where diamonds were found embedded in an altered volcanic rock. The mines known as Kimberley, De Beers, Du Toits Pan, and Bultfontein, all close together, were discovered in rapid succession, and an interval of nearly 20 years elapsed before another discovery—that of the Premier mine—was made there. The diamonds occurred at first in "yellow ground," which when followed downward, passed into "blue earth"; this is a volcanic product, apparently an olivine-diabase, much serpentinised, and in parts brecciated, filling pipes which pass through shales, associated with eruptive rocks. All these mines are in Griqualand West, which forms part of Cape Colony; but diamonds also occur elsewhere in South Africa, notably at Jagersfontein, in the Orange Free State, a locality which yielded in 1893 a huge diamond, called The Excelsior, said to weigh nearly 970 carats.

Many of the largest known diamonds which have acquired historic interest are represented by models, among which those of the celebrated Koh-i-noor claim especial attention. On the annexation of the Punjaub by the British Government, in 1849, the civil authorities took possession of the Lahore treasury,

under the stipulations that all the property of the State should be confiscated to the East India Company, and that the Koh-i-noor should be given to the Queen of England. In order to bring out its lustre and remove some flaws, this gem was re-cut after the Great Exhibition of 1851, under the direction of Messrs. Garrard, and its weight reduced from $186\frac{1}{16}$ carats, to $102\frac{1}{2}$.

In this Case will also be found glass models of the following celebrated diamonds, the weights of which are, where possible, expressed on the accompanying labels:—The Nizam; the Mattan; the Star of the South; the Mogul; the Regent, Pitt, or Orleans; the Orloff; the Tuscan; the Florentine, or Austrian; the Hope; the Dresden; the Nassuck; the Pigot; the Shah; the Sancy; the Eugénie; the Polar Star; the Cumberland; the Stewart; the first diamond found in S. Africa; Mr. Dresden's; the engraved Persian; and a diamond said to have been worn by Napoleon in the hilt of his sword. Some of these are, perhaps, of rather doubtful authenticity.

The impure variety of diamond called *bort* or *boort*, which occurs usually in small spherical nodules, having a radiated internal structure, is employed, in the state of powder, as a grinding and polishing agent; and much of the small splintery stuff from South Africa, is also called bort. The dark-coloured non-crystalline substance known as "*carbon*" or *carbonado* is largely used for arming the crowns, or steel drill-heads, of the diamond-boring apparatus for rock-drilling, and for tools used in dressing millstones, &c. This peculiar form of carbon was discovered in the diamond gravels of Bahia, in Brazil in 1842, and appears to furnish, in some of its characters, a transition from ordinary diamond to the next species—graphite.

Case B.—Graphite, &c.

The mineral known variously as *Graphite* (*grapho*, I write), *Plumbago* (*plumbum*, lead), and "*Blacklead*," is composed of carbon and a small but variable quantity of iron oxide, and other impurities. It occurs in granite, schists, and crystalline limestone, as also in nodules in eruptive rocks. It is occasionally found crystallised in thin six-sided plates; and a similar form is assumed by the *artificial graphite* or *Kish* formed during certain metallurgical operations. Examples of this are exhibited.

The plumbago from Borrowdale, in Cumberland, has long been celebrated for its fine quality, but the supply seems to be practically exhausted. The mineral was found in detached pieces, called, according to their size, *sops* or *bellies*. Plumbago is used largely in the manufacture of crucibles, and for the preparation of *black lead pencils*, as represented in this case.

By Brockedon's Patent here illustrated, the smaller pieces of plumbago are ground to an impalpable powder, which is subjected to enormous pressure, imparted by means of a screw press,

whereby the powder is rendered perfectly coherent. From the blocks thus formed slices are sawn, from which pencils of the best quality, and entirely free from grit, are formed.

In addition to the Cumberland graphite, specimens of the mineral are exhibited from Siberia, Ceylon, and Canada as well as from several other localities. Ceylon yields most of the plumbago used for crucible manufacture.

The remainder of this Case is occupied with some of the forms of *coal,* which are rich in carbon. The *mother of coal* or *mineral charcoal,* which often occurs between the layers of bituminous coal, is a soft fibrous material, readily soiling the fingers, and containing between 75 and 83 per cent. of carbon. The varieties of *coke* represent the carbonaceous constituents of coal as obtained artificially by processes of destructive distillation. There are also here some samples of the so-called "graphite," or *gas-carbon,* found lining the interior of gas retorts, and valued as a conductor of electricity.

The varieties of coal, occupying part of this Case and of the next, form a regular series, commencing with the non-bituminous stone-coal or anthracite, and passing thence through the ordinary bituminous coals to the recently-formed lignite or brown coal, in which the original structure of the wood is frequently retained.

Anthracite always contains a large per-centage of carbon, frequently upwards of 90 per cent., and but a small proportion of volatile constituents. As the anthracites become softer they are distinguished as *free burning* or *steam coals,* and these may pass into the ordinary *bituminous* varieties, as in the South Wales coal-field. (*See* Case of Coals in the Model Room B.)

The "*crystallised*" *coal* exhibits a very peculiar structure, known as *cone-in-cone,* whilst in the *peacock coal* we have a remarkable example of superficial iridescence.

Case C.—Coal, Jet, Amber, &c.

A large part of this Case is occupied by a continuation of the series of coals, and by various hydrocarbons more or less closely related to this series.

Cannel is usually regarded as a compact variety of coal which burns readily, with a clear flame like that of a candle, whence its name, *candle,* or, in local patois, *cannel* coal. Large quantities are raised near Wigan in Lancashire, and at Lesmahagow, about twenty miles from Glasgow. A fine block of Lancashire cannel stands in the Lower Hall, No. 53. The *Albertite* from Nova Scotia, valuable for gas-making, appears to be an asphaltic variety of cannel.

Lignite, wood coal, or *brown coal,* which frequently retains the original texture of wood, usually occurs in deposits of tertiary age. In Germany, and in many other parts of the continent, lignite is extensively worked, but in this country it is

raised only at Bovey Tracey, in Devonshire. The value of lignite as a fuel is far inferior to that of ordinary pit-coal and the "Bovey coal" is practically unused. The plants from the Bovey Tracey lignite deposits will be found in the Upper Gallery, Case 52.

Jet appears to be a compact variety of lignite. At Whitby the jet occurs in the upper-lias shale. It is found on the shore, being frequently thrown up after storms, and is also worked inland. Much of the common jet is now imported from Spain. Jet is the *gagates* of Pliny, a name derived from the river Gagas in Syria.

With the coals are introduced a few minerals, or rather rock-substances, which, although differing essentially from coal, nevertheless possess considerable economic value. Of these the most interesting is the *Torbane Hill mineral* or *Bog Head cannel* from the coal measures of Linlithgowshire. From this substance, which is well known as having been the cause of considerable litigation, were obtained, by distillation at a low temperature, certain hydro-carbons highly valued, partly for illuminating purposes and partly as lubricating agents. It is now, however, virtually worked out, and recourse is had to other oil-shales in the district.

The so-called *Kimeridge coal* is a bituminous shale occurring in the Kimeridge clay of Dorsetshire. Small circular discs of this shale are frequently found in the Isle of Purbeck, and pass under the name of *Kimeridge coal money*, but it is probable that they are simply the refuse pieces from which rings or armlets have been turned.

Hatchettine or *mineral tallow* is a hydro-carbon occurring in the nodules of clay ironstone from the South Wales coal-field; while *Ozokerite* or *mineral wax* is a substance of very similiar composition, found in considerable quantity in Moldavia, where it has long been used by the peasants and whence it is now largely imported for the production of paraffin and the manufacture of candles. Closely related to these are the substances grouped together under the general name of *Bitumen* or *mineral pitch*. The compact variety called *Asphalt* is represented by specimens from the mountain limestone of this country, and from the celebrated Pitch Lake of Trinidad. In this lake, which is a mile and a half in circumference, the bitumen is solid and cold near the shores, but gradually increases in temperature and softness towards the centre, where it is boiling. The ascent to the lake from the sea, a distance of three-quarters of a mile, is covered with a hardened pitch, on which vegetation flourishes.

The *Elaterite* or *mineral caoutchouc* is a soft elastic variety of bitumen having a peculiar odour, and occurring in the carboniferous limestone of Derbyshire, where it was first observed, at the forsaken lead mine of Odin, by Dr. Lister, in 1673.

Passing over a small group of mineral resins, found chiefly in deposits of lignite, the only other mineral which need be noticed in this section is the well-known substance *Amber*. The vegetable

origin of amber is inferred from its resemblance to certain recent resins, from its association with lignite, and from the occurrence of insects and other organic enclosures. Göppert named the tree supposed to have yielded most of the amber *Pinites succinifer* and Dana called the pure part of amber *Succinite.* The principal supply of amber is obtained from the Prussian coast of the Baltic; but specimens are occasionally found on the coasts of Norfolk and Suffolk. Some examples of amber from Cromer are here shown. A fluorescent variety found in Sicily, is known as *Simetite.*

Case D.—Sulphur.

Sulphur occurs chiefly in volcanic districts, such as Sicily and the Lipari Islands, and the Solfatara, near Naples. There are also important deposits in the Romagna and in Spain; whilst the sulphur of Iceland has also attracted attention, commercially. Most of the sulphur-yielding localities are well represented in the Case before us, and several of them have contributed finely-crystallised specimens.

The extraction of sulphur from the impure native materials, and the properties of the prepared sulphur, are also here illustrated. As native sulphur is usually contaminated with earthy matters, it is purified by a simple process of distillation. Sulphur is also largely extracted from iron pyrites (p. 75), a bisulphide of iron, which yields a considerable proportion of free sulphur on simple distillation.

At 226° Fah. sulphur melts to an amber-coloured liquid; if the temperature be then raised to about 400° Fah. it becomes dark brown, opaque, and thick; but heated yet higher it again becomes thin and limpid. If the thick tenacious sulphur at 400° be suddenly cooled by immersion in water, it forms a soft and transparent mass of considerable elasticity, and in this state may be used, as shown here, for receiving impressions of seals, &c.

The crystals of native sulphur, and those prepared by evaporation from solution at ordinary temperatures, are entirely distinct in form from the crystals which may be obtained by solidification from a state of fusion; and this difference in crystalline character is accompanied by a corresponding variation in density and other physical properties. The sulphur is, in fact, *dimorphous.*

With the sulphur-group will be found a fine specimen of the closely-allied but much less widely-diffused element, *selenium,* as prepared from the deposits of the copper-smelting furnaces of Mansfeld (p. 93).

Case E.—Rock Salt and other Salts of Sodium.

A specimen of crystallised *sodium* is placed here as representing the metallic base of the group of minerals which occupy this Case. Of these salts of sodium, the most important is the chloride or *common salt.* The greater part of our culinary salt

is manufactured from the brine springs of Cheshire and Worcestershire, which rise from beds of *Rock Salt.* The rock salt itself is largely worked at Northwich, in the valley of the Weaver, and near Belfast, in Ireland. A thick bed has been found at a considerable depth at Middlesbro'-on-Tees. The rock salt of Cheshire occurs, associated with gypsum, near the base of the New Red or Keuper Marl. Occasionally the salt is colourless and crystalline, but usually it is coloured to a greater or less extent by the presence of peroxide of iron. Although generally found in the New Red Sandstone, rock salt is by no means confined to this formation; the deposits, for example, of Wieliczka, in Poland, and Volterra, in Tuscany, occurring in tertiary marls: from both these localities specimens are exhibited.

The curious hopper-shaped crystals of salt here shown result from the aggregation of a number of small cubes formed on the surface of the brine during evaporation.

The Greenland mineral called *Cryolite* or *ice-stone* is a double fluoride of aluminium and sodium, important as a source of aluminium (p. 56). Attention should be directed to the unusually fine crystals of the rare mineral called *Glauberite,* a double sulphate of sodium and calcium, from Spain. The deliquescent nitrate known as *Cubic nitre,* or *Chili Saltpetre* has in recent years acquired great importance as a valuable fertilising agent.

Case F.—Borax, Salts of Potassium, Magnesium, &c.

The collection in this Case commences with a series of specimens of *Borax,* a hydrated borate of sodium, of which some fine crystals are exhibited from Borax Lake, in California, and numerous small crystals from a lake in Tibet, whence large supplies were formerly brought into commerce under the name of *tincal.* Here also are shown many specimens illustrating the preparation of *boracic acid* from the *soffioni* or volcanic fumaroles of Tuscany. The hot vapours from these vents, contain only a small proportion of boracic acid, but are made to pass through water, by which the acid is absorbed, and this weak solution gradually becomes more highly charged, as it is transferred from one lagoon to another; when sufficiently impregnated, the solution is evaporated by means of the steam from the springs. The specimens exhibited are from the works of the late Count Larderel, whose name deserves record as the founder of this branch of industry in Tuscany.

Among the salts of boracic acid may be noticed *Hayesine,* a borate of calcium, occurring in white reniform masses, scattered over the dry plains of Iquique in Chili, where it is called *tiza.* *Boracite* is a borate of magnesium, with chloride, remarkable for its electrical and optical properties. *Colemanite,* from California, and *Pandermite* from Asia Minor, are examples of

other calcium borates. The applications of the borates are well illustrated by a collection in the Gallery of Model Room B.

Of the salts of potassium only a small number occur native. The chloride was an extremely rare species until found some years ago in the salt deposits of Stassfurt in Prussia. Some fine crystals of this mineral, known as *Sylvine*, are here exhibited. The nitrate, called *Nitre* or *saltpetre*, is of considerable value, being extensively employed in the manufacture of gunpowder.

Alum is placed here as a salt containing, in its typical form, potash and alumina in combination with sulphuric acid and water. Such at least is the composition of ordinary alum, but in other varieties the potash may be replaced by soda or ammonia; indeed of late years the manufacture of ammonia-alum has largely superseded that of the potash salt. Alum was long manufactured on a large scale from the *alum slate* or *shale* of the upper lias of Whitby. The shale in various stages of decomposition, and some fine alum crystals are here shown.

Websterite, a sulphate of aluminium, discovered by Thomas Webster at Newhaven, in Sussex, is represented by various specimens which have gained admission here by their rather remote relationship to the alum group.

An interesting series of minerals from the salt-deposits of Stassfurt is placed in this Case. Borings for rock-salt in the neighbourhood of Stassfurt, near Magdeburg, in Prussia, revealed the existence, some years ago, of vast deposits of various salts of potassium overlying the sodium salts. This represents precisely the order in which they would crystallise from a solution containing both kinds of salts; the salts of sodium being less soluble than those of potassium and magnesium would separate first, leaving the more soluble compounds in the mother-liquor.

In this section are also placed a few minerals containing *magnesium*, such as *Brucite* and *Epsomite*. By the action of hydrochloric acid on carbonate of magnesium there is obtained a chloride, from which the metal is reduced by the action of sodium. Examples of the metal will be found in Case No. 35 (p. 57).

Case G.—Salts of Barium and Strontium.

The very widely-diffused mineral *Barytes*, or sulphate of barium, is frequently employed as a pigment, either alone or associated with white lead; and for this purpose the mineral is raised in Shropshire and in Ireland. From its density barytes is commonly known as *heavy spar;* while the massive earthy varieties often pass under the name of *cawk*.

Witherite, a carbonate of barium named after Dr. Withering, occurs in remarkably fine crystals near Hexham, in Northumberland, where it is worked commercially.

The two species of *baryto-calcite* and *alstonite* are double salts, being carbonates of barium and calcium.

The metal *strontium*, closely allied to *barium*, occurs in the form of sulphate and carbonate. The sulphate called *Celestine*, from the pale blue colour which it occasionally presents, occurs in fine crystals at Girgenti, in Sicily, associated with native sulphur. In the New Red Marl of Gloucestershire and Somersetshire Celestine is now rather largely worked, and thousands of tons are annually shipped from Bristol.

The carbonate of strontium known as *Strontianite* is found in the lead mines of Strontian in Argyleshire, a locality which originally gave its name to the mineral.

The salts of strontium are remarkable for the red colour which they impart to flame, those of barium giving a green tint.

Case H.—Gypsum, &c.

In connexion with the Case in the Lower Hall, illustrating the applications of *plaster of Paris*, this mineral—a hydrated sulphate of calcium—has already been described (p. 40). The crystalline character of *Gypsum*, or, as the transparent varieties are called, *Selenite*, is well shown by the perfect crystals which not unfrequently occur in deposits of clay and marl; a characteristic twin-form being seen in the fine arrow-headed crystal from the celebrated quarries of Montmartre, near Paris. Some beautiful specimens are shown from the New Red Marl of Newark in Nottinghamshire. Enormous crystals have recently been found in Utah. The beads and other objects of *fibrous gypsum* exhibit in a marked degree the pleasing lustre which has led to the name of *satin spar;* whilst the carving illustrates the application of the variety called *alabaster*, described at p. 28. The waterless sulphate of calcium, *Anhydrite*, has been already noticed (p. 40).

Cases I. and J.—Calcite.

Some idea of the great variety of forms assumed by this widely-distributed mineral will be gained from the numerous crystallised specimens grouped together in this section. On fracture, the crystals of calcite split with the utmost ease into regular six-sided solids, called rhombohedrons; and it was indeed in this species that the property of cleavage in minerals was first observed. Calcareous spar, or calcite, is a carbonate of calcium, or as it is more frequently called, a carbonate of lime, often containing impurities upon which depend the colours assumed by the mineral.

The highly transparent varieties are termed *Iceland spar*, the finest specimens being obtained in Iceland. This crystal is remarkable for its double refraction, the phenomena of which are well shown in the specimens exhibited. The power of refracting light doubly is, however, enjoyed in a greater or less degree by all crystalline minerals, except those belonging to the cubic system. Some remarkably fine specimens of calcite are

exhibited from Derbyshire, Cornwall, &c. Egremont in Cumberland has furnished some beautiful illustrations, including the interesting "butterfly twins;" whilst the Furness District in Lancashire has yielded crystals richly tinted with hæmatite. The Derbyshire scalenohedra are known as "dog-tooth spar."

Case K.—Carbonate of Lime, *continued.*

Many of the massive forms of carbonate of lime having been already described in connexion with the *marbles* (p. 22) in the Hall, it only remains to notice among the marbles here exhibited—the *giallo antico,* or yellow marble of Sienna, generally known as *Sienna marble;* the *onyx marble,* from Algeria and Mexico, a stalagmitic form similar to the "alabaster" of the ancients; and the *fire marble,* or *lumachella,* from the lead mines of Bleiberg, in Carinthia, remarkable for the brilliant iridescence of its fossils.

The Fontainebleau sandstone or *limestone* is an aggregate of rhombohedrons of carbonate of calcium, containing a large quantity of sand mechanically mingled.

In connexion with the varieties of carbonate of lime will be found some interesting examples of the production of *pearls* on the shell of the pearl oyster and pearl mussel, by the artificial process of introducing some object which will produce irritation to the mollusc.

A very distinct physical condition of carbonate of calcium is presented in the mineral called *Aragonite,* from having been first discovered at Aragon, in Spain. In addition to the fine rhombic crystals may be noticed the coral-like stalagmitic forms occurring chiefly in the iron mines of Styria, and known as *flos ferri,* or "*flower of iron.*"

Case L.—Dolomite; Apatite.

Carbonate of calcium frequently contains a variable amount of carbonate of magnesium, and when the two compounds occur united in nearly equivalent proportions, they form the species *Dolomite,* already noticed among the building stones (p. 33). As the proportion of magnesium increases, the species passes into *Magnesite,* or carbonate of magnesium.

The remainder of this case is occupied with a series of specimens illustrating the varieties and mode of occurrence of the valuable mineral called *Apatite.* In different varieties the composition of apatite varies, but it consists essentially of phosphate of calcium associated either with a chloride or fluoride of calcium, or with both. This mineral is not unfrequently found in company with tin ores. The extensive use of phosphate of lime as a fertiliser gives considerable commercial value to the deposits of this mineral occurring in Spain, Nassau, Norway, and Canada. The massive varieties are frequently called *Phosphorite.* With the minerals in this case are grouped a few

other phosphatic substances applied to similar purposes. In the lias, green-sand, and other secondary formations numerous *coprolites* and phosphatic nodules occur; and in some of the Crags of our eastern counties they are also found, with various mammalian and other animal remains. By the action of sulphuric acid these are converted into the soluble super-phosphate of lime, in which form they are largely employed for manure. Valuable phosphatic deposits are now worked in South Carolina and in Florida.

An extensive series of phosphates, of economic value, is shown in the gallery of Model Room B.

Case M.—Fluor-Spar.

The species *Fluor-spar* is here represented by a number of specimens, not less attractive by their variety of colour than by their beauty of crystalline form. The mineral, which is a fluoride of calcium, is found in nearly all our mining districts, especially in Cumberland and Derbyshire, Devon and Cornwall. It chief uses are as a flux in certain metallurgical operations, and as a source of hydrofluoric acid.

The violet-blue variety of fluor, known commonly as "Blue John," is used in the manufacture of tazze, as shown in this case, and of vases as exhibited in the Hall. The visitor will not overlook the magnificent Vase No. 27 (p. 53); or the fine collection of specimens of fluor-spar in the Ludlam cases (p. 13).

Case N.—Quartz.

Occurring under a greater variety of aspects than any other member of the mineral kingdom, the species *Quartz* necessarily claims a large amount of space, and hence it extends through this and the three succeeding Cases. Pure quartz consists simply of silica, or silicon dioxide. The mineral crystallizes in forms belonging to the rhombohedral system, and is sufficiently hard to scratch glass with facility.

Rock crystal is a pure transparent variety, frequently enclosing rutile, chlorite, various fluids, &c. Small brilliant crystals are often locally termed "diamonds;" such for example, are the so-called *Cornish diamonds, Bristol diamonds,* &c. Crystals which contain slender prisms of rutile, or oxide of titanium, known to the jeweller as *flèches d'amour,* or *Love's arrows,* are polished as ornamental stones. A more useful application of rock crystal is the formation of "pebble" lenses for spectacles.

Smoky quartz is a variety presenting a brownish tint, the term *morion* being applied when the colour becomes intense. The transparent brown and yellow crystals form the well-known Scotch stone, called from its locality *cairngorm;* whilst the bright yellow varieties are distinguished as *citrine* or *false topaz.*

Case O.—Quartz—*continued.*

Amethyst is another form of crystallised quartz, usually presenting a purple colour, due as some suppose, but perhaps incorrectly, to the presence of oxide of manganese. Amethysts are found in India, Ceylon, Persia, Brazil, Siberia, and various parts of Western America. The pink colour of *rose quartz* is probably referable to a slight admixture of oxide of manganese.

The eye will be arrested by the gold spangled appearance of the *Aventurine,* which seems to be generally due to the presence of minute scales of mica. The aventurine glass will be alluded to at p. 131. In the *cat's eye,* from Ceylon, the presence of parallel fibres of asbestos gives rise to a transverse luminous band, well seen when the stone is cut *en cabochon,* or with a convex surface. The brown South African *cat's eye,* or *Tiger-eye stone,* is composed mainly of silica and ferric oxide, and owes its fibrous structure to the presence of altered crocidolite. In the *ferruginous quartz,* or *Eisenkiesel,* the mineral is deeply coloured, and usually rendered opaque, by the presence of hydrous peroxide of iron. The specimens of *capped quartz* curiously show how a deposit of quartz has been thrown down upon a crystal of the same substance, with sufficient interruption to prevent perfect cohesion between the crystal and its cap; whilst the *pseudomorphs of quartz* suggest changes by which various minerals have impressed their specific forms upon the quartz, or have suffered removal, whilst the quartz has taken their place.

Case P.—Jasper, Flint, &c.

Passing from the crystallised varieties of quartz, we find here a group of siliceous minerals formed by the jaspery varieties, which are compact, opaque and more or less impure. The jaspers are usually coloured red or brown by association with oxide of iron. When the colours are in stripes the mineral is called *riband jasper,* of which some Siberian specimens are here exhibited. In the *Egyptian jasper,* which occurs usually in the form of rolled pebbles, the brown colours are disposed in concentric zones. The curious flexibility of the *flexible sandstone,* conspicuous in this Case, has been referred to the peculiar structure of the rock, the grains of sand being so loosely united as to enjoy a certain freedom of motion. Several impure forms of silica are presented in the shape of *hornstone, chert,* and *flint*: in flint the silica appears to be partly in the soluble and partly in the insoluble state. Flints occur chiefly in the upper chalk, in the form either of nodules or of regular bands: some characteristic examples will be found among the rock-specimens in the Upper Gallery. Some of the applications of flint receive illustration here, and a collection of flint implements is arranged in Table Cases Nos. 22 and 23 on the opposite side of the room (p. 51).

Case P.—Chalcedony, Agates, &c.

In this Case the flint-series is continued by specimens of silicified sponges and other organic remains preserved in flint. There are also here some curious examples of *beekite*, or orbicular silica. Then follows a beautiful collection of the different varieties of *chalcedony*, a translucent siliceous mineral, of a wax-like appearance, occurring often in stalactitic forms, and exhibiting a crypto-crystalline structure. Many of our most beautiful siliceous minerals are simply coloured varieties of chalcedony; oxide of nickel, for example, producing the apple-green tint of the *chrysoprase*, while peroxide of iron gives rise to the bright red tint of *carnelian*, and the deep reddish brown colour of *sard*.

Agates consist essentially of different kinds of quartz—chalcedonic, jaspery, and crystalline—disposed in successive zones, due to sequence of deposition from siliceous solutions. Whilst a few typical specimens are placed here, a large collection is exhibited in a neighbouring Table-Case No. 30, and described at p. 54. Regular alternations of light and dark coloured chalcedony are presented in the *onyx*, and on this depends its value for cameo work: when the layers consist of sard juxtaposed with strata of white chalcedony, the stone is called a *sardonyx*. A large number of cameos will be found here. *Heliotrope*, or *blood-stone*, is a chalcedony of a deep green colour, interspersed with blood-red spots of jasper, found in India, Iceland, the Island of Rum, Scotland, &c.

Case Q.—Opal; Alumina; &c.

In the *moss agate* and *mocha stone* placed in this Case, there are certain dendritic or moss-like delineations of an opaque brownish yellow or green colour, mostly due to oxide of manganese or of iron. These are followed by a large series illustrating the various kinds of *Opal*. In opal the silica exists in an amorphous, soluble, and usually hydrated condition, having solidified probably from a gelatinous or colloidal state.

The *precious* or *noble opal* occurs in porphyry at Czerwenitza, near Kashau, in Hungary, and, under similar conditions, in Honduras. The fine specimens from Queensland are obtained from the walls of fissures in nodules of ironstone. *The fire opal* is brought exclusively from Mexico, while *the common opal* is abundant as a secondary product in volcanic rocks in many localities. *Hyalite*, or *Müller's glass*, is a colourless transparent opal; while *menilite* is an opaque brown opaline concretion occurring in the tertiary strata of Menil-montant, near Paris.

The remainder of this Case is occupied by a fine series of specimens of *native alumina*. The coarser forms of alumina, or oxide of aluminium, having been already described under the names of *emery* (p. 39) and *corundum* (p. 90), it remains to notice, in this place, only those fine transparent varieties which, from

their excessive hardness and beauty of colour, are highly valued by the jeweller. These pure forms of alumina are obtained chiefly from Burma, Siam and Ceylon, where they occur in sands and gravels. The bright red varieties constitute the *oriental ruby,* so called to distinguish it from the distinct and much less valuable mineral, spinel, which is also known in commerce as "ruby." *Sapphire* is a name applied to the blue transparent crystals of corundum; Pliny's name of *asteria* being retained for the "star sapphires," or those varieties which exhibit a star of light when cut with a convex face. Sapphires of green, yellow and other tints are also exhibited.

The *spinel,* or *spinelle,* of which the bright red varieties are used as a gem under the name of *spinel ruby,* may be regarded as a compound of alumina and magnesia, the latter being frequently replaced to a considerable extent by protoxide of iron. Alumina and glucina constitute, in like manner, the *Chrysoberyl* or *Cymophane,* certain varieties of which, when cut *en cabochon,* exhibit a peculiar opalescence and luminous band, whence the name *oriental cat's-eye.*

Case R.—Emerald; Tourmaline; Topaz, &c.

The large series of minerals composed of various metallic silicates, in an anhydrous condition, commences in this Case and is continued through several of the following cases. In this section the visitor will probably be specially interested in such of the silicates as are cut and polished as ornamental stones.

The double silicate of the allied metals aluminium and glucinum, or beryllium, is known in its coarser varieties as *Beryl,* of which enormous six-sided crystals are found in the United States. The fine transparent green varieties are distinguished as *Emerald,* while those of paler tint pass under the name of *Aquamarine.* The rich colour of the emerald is due either to oxide of chromium, or to an organic colouring matter. The gem is chiefly obtained from the mines of Muzo in Colombia, where it occurs crystallised in a black limestones of cretaceous age. Specimens will be found showing its occurrence in the matrix, accompanied by some fossils from the limestone.

Closely related to the emerald in chemical composition is the mineral called *Euclase,* the excessive brittleness of which renders it useless for purposes of ornament. The American *beryllonite,* a phosphate of beryllium and sodium, and the Russian *phenakite,* a silicate of beryllium, are here exhibited both in the rough state and cut as gem stones.

Few minerals present greater complexity and variability of composition than the *Tourmaline,* to which we next pass. Its crystals are remarkable for a want of symmetry between the opposite ends, and for acquiring electric properties on exposure to heat. The black tourmaline is commonly known as *Schorl,* and the pink as *Rubellite;* a striking variation of tint in the

same crystal is well seen in the parti-coloured tourmalines from Elba, and from Maine, U.S.A.

The only other mineral of popular interest in this Case is the *Topaz.* This is a silicate of alumina associated with a silico-fluoride of aluminium. The topaz is found in the form of rolled pebbles, and in granitic rocks, commonly associated with quartz, and not unfrequently with tin ore. The yellow and the white topazes, chiefly from Brazil, form valuable gems; and in many cases a pinkish tint is developed by exposure to heat. The topaz of the ancients appears to have been the stone which we now call *Chrysolite;* this is a silicate of magnesium of a dull green colour, known also as *Peridot,* the name *Olivine* being applied to the less transparent varieties, commonly found in meteorites, and in basalt and similar rocks. Examples of these varieties are exhibited in the next Case, S.

Case S.—Zircon, Garnet, &c.

Many of the silicates exhibited in this Case are, like those in the last section, employed for purposes of ornament. *Zircon* is a silicate of the rare metal zirconium. The transparent coloured zircons are used as gems; the rich red varieties being distinguished as *Hyacinth* or *Jacinth,* and the less brightly coloured as *Jargoon.* The hyacinth occurs in the form of rolled crystals, chiefly in Ceylon and central France; whilst the coarse dull-coloured *Zirconite* forms a constituent of the zircon-syenite of Norway, and some other rocks. Microscopic zircons are not uncommon in such rocks as granite.

The group of *Garnets* embraces a considerable number of minerals which are essentially double silicates, the varieties depending on the character of the bases. The deep-coloured *Almandine* or *precious garnet,* a silicate of aluminium and iron, is frequently cut *en cabochon,* when it is known as *Carbuncle;* and the *Essonite* or *cinnamon stone* is also used as a gem, being often mistaken for hyacinth. Essonite is a silicate of aluminium and calcium, thus having a composition similar to that of the Siberian *Grossularia* or *gooseberry garnet.* Other Russian garnets are the *demantoid,* a stone of great brilliancy, when cut, and the *Uwarowite,* a mineral having a bright emerald-green colour, and containing the silicates of calcium, aluminium, and chromium. The species *Idocrase* or *vesuvian* has a composition identical with that of certain garnets, but crystallises in forms totally distinct.

Case T.—Felspars.

The minerals in this Case, although less attractive than those in the preceding sections, are nevertheless of the highest interest as rock-constituents. The Case is devoted to the family of *Felspars,* which includes a number of species, of which the best

known is the potash-felspar, *Orthoclase.* The transparent orthoclase called *Adularia* is used for purposes of ornament under the name of *Moon-stone.* The opalescent orthoclase from the syenite of Fredriksværn, in Norway, was formerly regarded as microcline. *Amazon stone* is a variety of microcline, noticeable for its beautiful apple-green colour. *Obsidian* or *volcanic glass,* is a vitreous form of felspathic lava employed by many savage races for making cutting instruments; it was largely used in this way by the ancient Mexicans. The plagioclastic section of the felspar group comprises such species as crystallise in the triclinic or doubly-oblique system. *Albite* and *Oligoclase* are closely-related felspars, the former containing soda and the latter both soda and lime. The Norwegian *Sun-stone* or *Aventurine-felspar* is, in part, a variety of oligoclase, notable for enclosing certain minute crystals from which light is brilliantly reflected. Attention need scarcely be directed to the beautiful play of colour exhibited by the polished slabs and cameos of the soda-lime felspar called *Labradorite.* The mineral was first sent to England by the Moravian missionaries in Labrador.

Case θ.—Various Anhydrous Silicates.

In this Case the large series of anhydrous silicates is continued with the well-known *lapis lazuli.* This is a composite mineral substance, of which the essential part has been separated in a pure state, and is called by Brögger *lasurite.* The lasurite seems to be a silicate of aluminium and sodium, with sodium sulphide and sulphate; in the lapis itself calcium is always present. Lapis lazuli occurs generally in crystalline limestone, in Persia, Bokhara, China, Siberia, &c. The richer varieties of lapis lazuli are employed in the manufacture of ornamental articles; and when subjected to careful powdering and washing, to free it from all foreign admixtures, the mineral forms the *ultramarine* of the artist.

An artificial ultramarine is prepared by carefully heating a mixture of clay, carbonate of soda, and sulphur. Examples of the genuine and of the artificial ultramarine stand side by side.

Several beautiful crystallised minerals such as *Scapolite, datolite,* and *epidote* are fairly represented in this Case, but as they have no general interest, any notice would be out of place here. The visitor will, however, be attracted by the pink slabs of the Norwegian *Thulite* and the Siberian *Rhodonite,* as also by the emerald-like *Hiddenite.* Some specimens of *jadeite* from China, Burma, and Mexico, are illustrations of a material often confused with the jade exhibited in the next Case.

Case U.—Augite; Hornblende; &c.

Here the visitor will find a very instructive group of silicates embracing the different varieties of the closely-allied rock-

forming minerals *Augite* or *Pyroxene* and *Hornblende* or *Amphibole.*

Jade or *nephrite* is well known as a mineral which, in spite of its hardness, is largely carved into images and ornaments of various kinds by the Chinese; and it was also worked by the Maories of New Zealand. It should be mentioned, however, that at least two distinct minerals were formerly confounded under the general name of jade. The true jade is essentially a silicate of calcium and magnesium, being in truth a hornblendic mineral, while the species *jadeite,* often mistaken for it, is a silicate of aluminium and sodium. The name nephrite is derived from the Greek *nephros,* kidney—in allusion to its having been used by some peoples for the cure of diseases of that organ. Some fine Chinese carvings in jade and jadeite are in Case 54.

The fibrous forms of hornblende and similar minerals are known as *Asbestos* (*inconsumable*), from their power of resisting the action of intense heat; hence asbestos cloth, woven from the fine threads, may be exposed to fire without being consumed. The delicate fibres are distinguished as *mountain silk,* while the massive forms resulting from the interlacing of these fibres are called, according to their texture, *mountain leather, rock cork, &c.* Asbestos is now extensively employed as a material for jacketing steam-pipes, for fire-proof roofing and flooring, for packing safes, &c. Much of the asbestos, such as that from Canada, is a fibrous form of serpentine, known as *chrysotile.*

Case V.—Mica; Steatite; &c.

The members of the *Mica* family, of which many representatives are exhibited, differ from one another in optical and other physical characters, as also in chemical composition. They are important as constituents of granite, mica schist, and other rocks. A portion of an unusually large crystal of Canadian mica (*phologopite*) will be found in the lower part of the Central Case, with the Australian model, in the Model Room A. (p. 135).

The mica-group is usually divided into two branches, known as the light and the dark micas; the former being represented by the common species *muscovite,* or potash-mica, and the latter by *biotite,* a ferro-magnesian mica. All the micas contain more or less water, and stand perhaps intermediate between the hydrous and anhydrous silicates. In the mica-like minerals forming the group of *chlorites* combined water is always present, usually to the extent of upwards of 10 per cent., and the minerals are true hydrates.

In this Case will be found the familiar *Meerschaum* ("*sea foam,*") or *Ecume de mer,* so called in allusion to its lightness and white colour. This is a hydrous silicate of magnesium, found in Asia Minor, Turkey, Greece, &c.

Another mineral exhibited here is *Steatite* which frequently occurs in association with serpentine, as in the Lizard District

in Western Cornwall. The mineral is remarkably unctuous to the touch, and is hence popularly termed *soapstone:* advantage is taken of this property in using powdered steatite for causing new gloves and boots to slip on readily; the variety employed for this purpose being generally known as *French chalk.* Soapstone resists the action of heat and has been employed for gas burners and for lining stoves; at one time it was used in the manufacture of porcelain at the Worcester Works. When lamellar it is generally known as *Talc,* a name frequently applied improperly to mica; the two are however easily distinguished, the talc being flexible but not elastic, whilst the mica enjoys great elasticity.

Case W.—Serpentine, &c.

Enough has already been said of serpentine as a rock, when describing the fine objects in the Hall (p. 28). Other examples of this ornamental stone are in this Case, where also will be found specimens of *noble* or *precious serpentine,* a variety of oil-green colour, slightly translucent; of *chrysotile* and *picrolite,* the one a fibrous and the other a columnar variety; of *marmolite* and *antigorite,* the former a foliated, and the latter a lamellar form of serpentine.

It is the mineralogical student rather than the general visitor who will be interested in most of the other minerals in this case. The *Lemnian earth,* formerly valued in medicine, was esteemed sacred by the ancient Greeks, being mixed with goats' blood, and made into cakes, which were then stamped by the priests, whence it was called *sealed* or *sacred earth.* From the use of the *Agalmatolite* by the Chinese for carving figures it has received the names of *figure stone* and *pagodite.* Several distinct substances, however, are used for these Chinese carvings. The white powder labelled *Kaolinite* represents in a state of purity the hydrous silicate of aluminium which in less pure forms constitutes part of our *kaolin* or *China-clay* (*see* p. 120).

Case X.—Zeolites.

The *zeolitic minerals* occupying this and the following Case are related by several characters in common. They may be regarded as essentially hydrous silicates of alumina with an alkali or an alkaline earth; and are usually found in the cavities of amygdaloidal trap-rocks, some, however, occurring also in metalliferous veins. Beautiful in their crystalline forms, and interesting in their chemical composition and mode of occurrence, the zeolites are highly attractive to the mineralogist, but they receive no practical applications. The principal species represented in this Case are *Prehnite,* a hydrous silicate of aluminium and calcium, of which some examples are exhibited from the igneous rocks of the Dumbarton Hills; *analcime,* a hydrous silicate of aluminium and sodium, often containing also potassium and calcium; and *apophyllite,* a mineral differing from

the true zeolites in that it contains no alumina, being in fact a hydrous silicate of calcium and potassium. Especially noteworthy are the fine Indian crystals of apophyllite brought to light during the cutting of the railway tunnels on the stupendous inclines ascending the Bhore and Thul Ghauts.

Case Y.—Zeolites.

Here the visitor will find a large number of beautiful zeolitic minerals, which it is unnecessary to describe in detail. The differences in chemical composition are sufficiently explained by the accompanying labels. Among the more noteworthy species attention may be called to *natrolite*, in beautiful needle-like crystals; *chabasite*, in fine rhombohedral forms, almost like cubes; *harmotome*, in milk-white twin-crystals, as though two individuals were crossing each other; and *stilbite* in crystals with broad cleavage planes exhibiting a pearly lustre. The salient characters of many of these species are sufficiently explained by their popular names, such as foliated zeolite, needle-stone, radiated zeolite, effervescing zeolite, etc.

Case Z.—Turquoise, &c.

A few minerals containing phosphate of aluminium are grouped together in this, the last division of the Horseshoe Case. *Childrenite* is a phosphate of aluminium, iron, &c. found in a few localities only in Devon and Cornwall, and named after the late Mr. Children, of the British Museum. *Wavellite* is a mineral occurring chiefly in small globular concretions, which when broken present a beautifully radiated structure; the species takes its name from Dr. Wavell, who discovered it at Barnstaple in Devon. *Vivianite* is a hydrous ferrous phosphate, which on exposure to the air becomes of a deep blue colour, and is not unfrequently found with phosphatic remains, such as fossil bones. Passing over a few other rare species, the visitor will be attracted by the specimens of *Turquoise*. This mineral is a hydrous phosphate of aluminium, containing copper; and when of fine colour is valued as an ornamental stone. The finest specimens are found near Nishapur, in Persia, and some years ago discoveries were made in Arabia Petræa. Ancient workings have of late years been re-opened at Los Cerillos, in New Mexico, where it occurs in a trachytic rock; but much of the Mexican turquoise is of too greenish a tint. Some have supposed that this stone was the famous *chalchihuitl* of the ancient Mexicans.

In addition to the true *oriental turquoise* described above, the jeweller avails himself of a substance somewhat similar in general appearance, but known as *occidental turquoise*. This is the *odontolite* of mineralogists, a substance which appears to be nothing more than fossily ivory, bone, or tooth, coloured with phosphate of iron.

CERAMIC AND VITREOUS SERIES.

A large collection illustrating the ceramic and vitreous manufactures, especially rich in illustrations of the history of British Pottery and Porcelain, is exhibited at the southern or Jermyn Street end of the Principal Floor, where it is entirely separated from the mineralogical and metallurgical collections. The ceramic and vitreous collection is arranged partly in a series of forty-four Wall Cases distinguished by Roman numerals, partly in Glass Cases which rest on the cornice of the balustrade on each side of the staircase leading from the Hall, and partly also in several Pedestal Cases in the neighbouring area. It is not considered necessary to do more than give a very brief description of the Collection of Pottery and Porcelain, since the subject is treated in detail in the *Handbook* specially devoted to this Department.

It will be desirable to commence the study of the ceramic series by noticing the raw materials used in the manufacture. Examples of these materials will be found in the lower compartment of the Pedestal Case No. 53 and a valuable series of British clays, collected and presented by Mr. George Maw is exhibited in the lower divisions of the several Pedestal Cases (Nos. 52, 53, 56, 62, 63, 64) occupying the two embayments.

Clay, the plastic material upon which all ceramic manufacture depends, is essentially a hydrous silicate of aluminium, its peculiar fictile properties being generally regarded as due to the presence of the combined water.

The clays exhibited include specimens of China clay, Cornish clay, or kaolin; Bovey clay from Devonshire, and Poole clay from Dorsetshire. The other raw materials comprise samples of China stone and of flint; the former is a granitic rock having its felspar only partially decomposed and retaining much of its alkaline silicate.

A small series in the lower part of Case No. 53 illustrates the *manufacture of pottery,* but it is contemplated to replace these specimens, which are now antiquated, by a more modern series. A description of the processes of manufacture will be found in the Pottery Handbook.

Case No. 63 on the western side, contains a miscellaneous series collected for the purpose of illustrating different kinds of *glazing.* It commences with certain glazed bricks from Assyria and Babylonia, and with the well-known blue-glazed frits of Egypt, such as the small turquoise-blue sepulchral figures, glazed with a silicate of sodium and copper. The use of white enamel, or a glaze rendered opaque by means of binoxide of tin, or stannic oxide, is illustrated by certain tiles from the Alhambra, several dishes of majolica ware, a sample representing Palissy's rustic ware, and some specimens of Delft: in all these examples the brilliant white ground is obtained by the use of a stanniferous glaze. Felspathic glazes are represented by many pieces of oriental porcelain, including some tiles from the Porcelain Tower at Nankin assigned to the year 1411. Salt glaze is

largely employed on stoneware and was formerly used in the Staffordshire potteries for glazing delicate ornamental objects, as illustrated in Wall Cases Nos. I. to V.

A Table Case, No. 57, on the east side, contains a collection of materials used for *painting on pottery and porcelain.* These consist usually of a flux, or vitrifiable substance, mixed with the colouring agents, which are generally metallic oxides. Some few colours, such as the cobalt blues, can be used on the biscuit ware, and are therefore *underglaze* colours, but most are employed on the ware after glazing, and are vitrified by subsequent firing at a very moderate temperature.

A small but characteristic series of ancient *Greek Vases* will be found in the Glass Case (No. 70) on the bridge across the staircase leading from the Hall. These specimens have been selected, not so much for their historical and artistic interest as for sake of illustrating the nature of the paste, the glaze, and the colours which were employed in their production.

The historical series illustrating the development of ceramic art in this country, though good in most departments, is by no means rich in very early examples. A small cinerary urn, found at Tarradale in Ross-shire, and placed in pedestal case No. 64, is a characteristic piece of *ancient British pottery. Roman pottery* is represented by a rather large collection in this Case, including some excellent examples of the red lustrous ware, commonly called "Samian." Many of the specimens here exhibited were obtained from the collection of the late Mr. Chaffers, and were dug up, some half century ago, during improvements in Cannon Street, and other parts of the City of London. There are also some fine examples of Roman ware from Castor, near Peterborough, discovered by Mr. Artis, and presented by the late Earl Fitzwilliam. Much of the Castor ware is ornamented with scrolls and figure-subjects in relief, laid on in white clay or *engobe.* The Romano-British pottery of Upchurch, at the mouth of the Medway, is amply represented by a collection given by Mr. J. C Gooden, and exhibited in the lower compartments of two Cases in the Vitreous series, Nos. 67 and 69.

A small collection of Roman Pottery from the Rhine, for comparison with that found in England, and including some fine examples of Samian ware, will be found in the upper part of the Pedestal Case No. 64. Much of the Samian ware found in Britain was no doubt imported from the Continent, but it seems probable that some at least was manufactured in this country.

A collection of *mediæval pottery* found in Britain, principally in the City of London, is placed on the upper shelves of the range of Wall Cases I. to V. Here will be found several jugs or pitchers of Norman type; pilgrims' bottles, with handles perforated for suspension; "grey-beards," or Bellarmines, in brown stoneware, with a grotesque mask under the spout; and a green-glazed puzzle jug of "Tudor ware," dated as early as 1571.

The collection of *Staffordshire pottery* commences in the Wall Cases I. to V., and is continued throughout the range of cases along the eastern wall. Among the earliest productions of the district, now famous as "The Potteries," are the curious *butter-pots* and the *tygs*, or drinking-cups furnished with more than a single handle. The *slip ware* is a coarse brown material, ornamented in relief with white clay or "slip," and coated with a brilliant lead-glaze. Some of the designs on the *Toft ware*, such as the dish G. 25, so-called from a famous maker, are extremely quaint. Other early products of the Potteries are seen in the specimens of *agate ware* and *tortoiseshell ware*. The red unglazed *Elers' ware* represents the work of the two brothers Elers, who came from Holland with the Prince of Orange in 1688. A large and valuable display of old *salt-glazed ware*, sometimes called *Crouch Ware*, and quite incorrectly, *Elizabethan ware*, occupies the lower part of these Cases.

On the upper shelves of the range of Wall Cases VI. to X., will be found an illustrative collection of the manufactures of Josiah Wedgwood. Wedgwood was born in 1730, and as a boy worked as a thrower in a small pottery belonging to his father. In 1759 he commenced for himself in an humble way, manufacturing small ornamental articles. He very much improved the *Cream Ware* of the time, first made by Enoch Wood, and having introduced it to Queen Charlotte, he received permission to call his manufacture *Queen's Ware*. Associated in partnership with Mr. Bentley of London, Wedgwood succeeded in securing the assistance of artists, such as Flaxman, and the support of the patrons of art. From this time may be dated those beautiful productions which are so associated with the name of Wedgwood—vases, cameos, medallions, and the like, which have not been excelled by any manufacturer since his time. A fair selection of these will be found in the collection, showing the great variety of manufactures in which he engaged. Perhaps the most beautiful example is a copy of the famous Portland vase. A fine collection of Wedgwood's cameos, some in black *basaltes* or *Egyptian ware*, and others in the delicate *jasper-ware*, will be found in two Cases (No. 58), placed one on each side of the pillar opposite to Wall Case VIII.

As a noble example of Wedgwood's productions, a copy of a large Greek vase in the British Museum collection should be noticed, No. 51. This, the largest work executed by Wedgwood, was presented to the Musum by the late Mr. Apsley Pellatt; the original was formerly in Sir W. Hamilton's collection.

Whilst the upper part of the Wall Cases numbered VI. to X. is devoted to illustrations of Wedgwood's ware, the lower shelves of these Cases are occupied with examples of *old Staffordshire pottery*, showing the character of the manufacture as carried on by his contemporaries and successors. The series commences with some of the old ware of Ralph and Enoch

Wood, and passes on to the productions of Mayer, Neale, Turner, Shorthose, Adams, Wilson, Mason, and other well-known Staffordshire potters. The *Spode ware* may be regarded as a connecting-link between the wares in this series and those of Copeland and Garrett, which take a prominent place in the collection of modern Staffordshire products exhibited in the Wall Cases on the opposite or western side of the Museum

A range of Wall Cases placed under the windows, at the southern end, overlooking Jermyn Street, is devoted to an illustrative collection of *English Porcelain*. The series commences in Cases XI. and XII., with examples of *Bow Porcelain*. It is generally believed that these works were established about the year 1730, and continued in operation until 1775 or 1776. The examples include several fragmentary pieces dug up at Bow in 1868, and an inkstand inscribed "Made at New Canton, 1751." The "goat-and-bee jug." and several other pieces marked with an incised triangle, may be of Chelsea rather than Bow manufacture. The *Chelsea porcelain* is well represented in Cases XIII. and XIV., many of the pieces being marked with an anchor in relief, in gold, or in red. In 1766 the Chelsea works were purchased by Mr. William Duesbury, who was carrying on the manufacture of porcelain at Derby, and the union of the two establishments was recorded on the Chelsea-Derby china by blending the mark of the Chelsea anchor with that of the Derby . The collection of *Derby Porcelain* extends from Case XV. to XIX., and includes many pieces selected and described by the late Mr. Haslem, the historian of the Derby works. A fine series illustrates in chronological sequence the various marks used from time to time at this factory. Attention may be called to the delicate figures of Diana and Mars in Derby biscuit; to the painted figure of Quinn as Falstaff; to the highly-finished paintings on porcelain plaques by Mr. Haslem; and to the gorgeous decoration of the old "Japan patterns" on some of the Crown-Derby China. A few samples of *Pinxton Porcelain* are on the bottom shelf of Case XIV.

All the English porcelain previously noticed has been of soft paste, but the early production of a true hard paste, made with kaolin and china-stone, is illustrated by the *Plymouth Porcelain* in Cases XX. and XXI. The manufacture was started by Mr. William Cookworthy, of Plymouth, who about the year 1750, had discovered Kaolin and China-stone in Cornwall, and who obtained a patent in 1768, for the production of hard-paste china. The Plymouth works, after being carried on for a few years at a great loss, were closed in 1771; and the manufacture was transferred to Bristol, where it was conducted by Mr. Richard Champion. The *Bristol Porcelain* is represented in Cases XXII. and XXIII., where some rare and characteristic pieces will be found, bearing the distinctive mark of a cross in blue. The lower shelves of these Cases contain a display of Bristol earthenware.

Rockingham ware occupies Case XXIV., and is represented by some very fine examples presented by the late Earl Fitzwilliam. The works were situated at Swinton, near Rotherham, in Yorkshire; and about the year 1820 they produced, under Mr. Thomas Brameld, some splendidly-decorated porcelain. The pattern plates for a service for King William IV., exhibited in this case, may be accepted as typical of the best work. With the Rockingham earthenware will be found examples of the well-known brown-glazed "Cadogans," or tea-pots filled from the base.

A large and illustrative collection of *Worcester Porcelain* occupies the range of Cases XXV. to XXX. The manufacture of soft paste china was established here by Dr. John Wall, a local physician, in the year 1751. Much of the early china was composed of a frit body, and in the inferior kinds steatite, or soap-stone, was used. The wares of China and Japan were freely copied, and even the oriental marks imitated. One of the earliest marks was a cursive *W* in blue, an initial suggestive alike of the place and of the founder of the works—Worcester and Wall. A blue crescent was also commonly employed. The collection is rich in marks indicating the successive changes in the proprietorship of the works. Attention should be directed to the examples of early transfer-printing over the glaze, as seen in such pieces as the famous King of Prussia mug, with an engraved portrait by Richard Hancock.

Cases XXXI. and XXXII. are devoted to a collection of the pottery and porcelain of *Shropshire*, commencing with the black glazed ware of Jackfield. Of Turner's blue-printed china, made at Caughley, near Broseley, there is a fairly large series, serving to show the close resemblance of the Salopian porcelain to some of the Worcester china. Turner's china is marked either with the letter C, the initial S, or the word "Salopian." The Coalport or Coalbrook Dale china, made originally by John Rose, is illustrated by some beautiful specimens, many of which are direct imitations—even to the marks—of the productions of Sèvres, Dresden, and Chelsea.

Swansea ware occupies the next Case, No. XXXIII., and the collection comprises some fine examples of the so-called "opaque china," with natural-history subjects painted with much fidelity by Mr. Young, the draftsman employed by Mr. Lewis Weston Dillwyn. There will also be found here some pieces of genuine Swansea porcelain.

In the following Case, No. XXXIV., is a fine collection of the rare *Nantgarw porcelain*, made near Cardiff, at a factory established by Billingsley and Walker in 1813. The specimens serve to illustrate the remarkable translucency of the paste and the admirable flower painting in Billingsley's clever style. The lower shelves of Case XXXIV. are occupied by a small collection of *Lowestoft china*. A soft paste was first made at Lowestoft as far back as 1757, and the manufacture was continued until the

beginning of this century. The hard paste, sometimes assigned to Lowestoft, seems to be mostly oriental china.

The range of cases along the Western Wall, numbered XXXV. to XXXIX., contains in the upper part a large collection of *Modern Staffordshire ware,* including some beautiful specimens from the Exhibition of 1851, by Copeland and Garrett, Minton, and other makers. The series is continued in an adjacent Pedestal Case, No. 62, where will be found some exceptionally fine examples of the productions of the Staffordshire potteries, from the Great Exhibition, illustrating the condition of our Ceramic art nearly half a century ago. On the upper shelves of the Wall Cases numbered XXXIX. to XLIV. are exhibited some beautiful examples of modern *Majolica ware,* by Messrs. Maw and Co., of the Benthall Works, near Broseley, in Shropshire. With these are placed some admirable specimens of the various ornamental wares made at the Lambeth works by Sir Henry Doulton, and including examples of the decorative stone-ware which has become so famous as *Doulton ware.* Near the Lambeth ware are some excellent examples of the terra-cotta made at *Watcombe,* near Torquay.

The lower division of the range of Wall Cases XXXV. to XXXIX. is occupied mainly by the productions of the *Yorkshire potteries.* Here the cream-ware of Leeds is conspicuous, but there are also examples of the Don, Castleford, and Ferrybridge works. Attention should be directed to the specimen of *Place's ware,* made at the Manor House at York, and presented by Sir Wollaston Franks. Some good examples of *Liverpool pottery* are also exhibited, including some very large punch-bowls in blue-painted delft ware, some of which are placed, on account of their size, on the top, and others on the bottom shelves. The shelf below the Leeds and Liverpool ware contains a miscellaneous collection of old English mugs, many of which are interesting for the quaint mottoes they bear, or for the historical events which they commemorate. Below these are examples of the pottery of Fulham, Mortlake, Isleworth, Lambeth, and Vauxhall; whilst on the bottom of the Cases is a fine display of *Delft ware.* The characteristic of true delft is that, however coarse the body may be, the surface is coated with a fine dense white glaze, rendered opaque by the presence of oxide of tin, and upon this enamelled ground designs may be painted in colour, usually in cobalt-blue. Many of the specimens here exhibited bear early dates, such as the blue-painted mug dated 1631 ; the sack-pot, 1646 ; the white-wine jug, 1647 ; the claret-pot, 1662 ; and the candlestick, with arms of the Fishmongers' Company, dated 1648. The most characteristic pieces are the wine-jugs, the pill-slabs, the caudle-cups, the puzzle-pots, and the punch-bowls. Some were made at Lambeth, and others probably at Bristol and Liverpool ; whilst a few may be imported pieces from Holland. A fine series of delft dishes, coarsely painted with portraits of English kings and queens,

will be found on the bottom shelf of Cases XXXIV. to XLIV.; they include rude portraits, mostly full length, of Charles II.; Charles II. and Catherine of Braganza; James II.; William III.; Mary, the Queen of William III.; William and Mary; and Queen Anne.

On the shelves occupying the lower part of Cases XXXIX. to XLIV., above the delft dishes but below the Watcombe and Doulton ware, are examples of Nottingham brown-glazed ware, Newcastle and Sunderland pottery, and the wares of Lowesby, in Leicestershire; Yarmouth, Wrotham, and Cadborough. Some of the beautiful porcelain of Belleek, in Co. Fermanagh, is also exhibited.

Glass.

Cases 52, 53, 66, 68, 71, 72.

The manufacture of glass, from its intimate relation to certain branches of ceramic art, receives appropriate illustration in this section of the Museum.

Glass consists of a fused mixture of various acid silicates, usually transparent and insoluble, and always destitute of crystalline structure. In a free state silica, or silicon dioxide, is highly refractory, but when associated with certain metallic oxides, the resulting compounds are often eminently fusible. The degree of fusibility enjoyed by these artificial silicates is dependent partly on the nature of the base and partly on its proportion, those silicates which contain an excess of base being most fusible, and therefore most easily worked. In practice, however, glass always contains a large preponderance of silica, since it happens that the basic silicates, especially those of the alkalies, are frequently soluble, and hence to a great extent useless for those purposes to which glass is ordinarily applied.

Excluding those oxides which are introduced simply as colouring or decolouring agents, the bases practically employed in glass-making are potash, soda, lime, and oxide of lead; but for these bases other oxides may be substituted, as in the zinc and manganese glasses exhibited in Case 52; whilst, on the other hand, the silica may be replaced by boracic acid, as in Faraday's "heavy glass," a silico-borate of lead, of which a specimen will be found in the same case.

One of the most essential properties of glass is its amorphous or non-crystalline character. If, however, the glass be maintained long in a heated condition, its individual silicates have opportunity to crystallise, and the glass then becomes, to a greater or less extent, *devitrified*. Several specimens of bottle "metal," and other glasses, are exhibited, in which crystalline products are embedded in a vitreous matrix. By subjecting glass for a considerable time to a temperature somewhat below its melting point, complete devitrification may be effected, and an opaque white fibrous product is obtained, known as *Réaumur's porcelain;* of which samples are here exhibited.

Flint Glass is composed of a mixture of silica, alkali, and oxide of lead. Formerly the silica was introduced in the shape of calcined flints, whence the name "flint" glass, but at the present day sand alone is employed. The chief localities in England for glass-making sand are Alum Bay, Lynn, Aylesbury, Wareham, Reigate, and the New Forest; but it is not always of sufficient purity for flint-glass manufacture. Large quantities are also derived from Fontainebleau, in France, and from America, Australia, and New Zealand. The sand is prepared for use by simple washing and calcining, or if necessary by treatment with hydrochloric acid.

To remove the colour imparted to the glass by impurities in the raw materials, especially iron and carbon, certain oxidizing agents are always mixed with the raw materials. Of these oxygen-yielding substances, the most common are nitre or saltpetre, arsenious acid or white arsenic, and pyrolusite or peroxide of manganese. An excess of manganese produces a violet colour; and even when at first there is no appearance of colour in the glass, it will upon exposure to sunshine be gradually developed. Instances of this pink or violet tint are exhibited in the cases before us, and the same thing is strikingly shown by much of the plate glass in the roof of the building.

The details of glass-working are illustrated by a series exhibiting the successive stages in the manufacture of a wine-glass; and several of the simple tools of the glass-worker are exhibited, viz., the *pucellas*, the *spring tool*, and the *wood tool*. The mode of blowing glass in metallic moulds is also illustrated.

Many of the specimens in Case 52 were used by the late Mr. Apsley Pellatt in illustration of his lectures at the Royal Institution, afterwards published under the title of "Curiosities of Glass-making." (1849.)

Among these specimens attention may be directed to an example of *cameo incrustation* of much interest. The figure, usually made of porcelain clay and sand which has been previously fused with carbonate of potash, is formed in a plaster of Paris mould, and slightly baked. It is then heated to redness, and being placed within a cylindrical flint-glass pocket, the open end is heated and welded together by pressure, so that the figure is in the middle of a hollow hot mass of glass. The whole is re-warmed and the workman exhausts the air by his mouth from within, by means of the tube to which it is attached, and thus by atmospheric pressure the whole becomes a homogeneous body.

An incrusted inscription is another example of a similar character; the letters are drawn upon a piece of glass with a vitrified black paint, and burnt in; the inscribed glass is introduced at nearly a red heat into a glass pocket, and treated as already described.

Case 52 also includes a series of modern *Venetian enamel cakes*, and a collection of *glass beads* used in the African and

Indian trades. The art of making glass beads was first discovered in Murano, where the trade is still great. Here also will be found pieces of enamelled, painted and etched glass, &c. *Etching on glass* may be effected by covering the glass with a coating of wax, and then with a needle removing it along the lines to be etched. The drawing being formed, the glass is exposed to the action of hydro-fluoric acid, liberated from fluor-spar by the action of sulphuric acid. Most glass, however, is now etched by means of the sand blast.

Toughened glass is prepared by plunging the finished article into oil or melted fat at a high temperature. Glass may be also hardened by rapid and uniform cooling, as practised by Mr. Siemens, of Dresden.

ANCIENT GLASS. *Case* 53.—Specimens of Assyrian, Babylonian, Egyptian, Greek, and Roman glass are here exhibited.

The *cinerary urns* of green glass will be inspected with much interest: and of these Mr. Apsley Pellatt writes, "The round vases are of elegant forms, with covers and two double handles, the formation of which must convince any one capable of appreciating the difficulties which even the modern glass-maker would have to surmount in executing similar handles, that the ancients were well acquainted with the art of making round glass vessels." One of the bottles found at Nismes has been formed by being blown in a mould. The *lachrymatories*, which probably contained the unguents and aromatics which it was usual to deposit with the dead, have been so called from the romantic notion that these bottles, usually found in tombs, were filled with the tears of the mourners.

The Roman glass beads, from the number of them which have been discovered in various parts, must have been much in use. Here, too, will be found some examples of so-called "Druidic beads." These beads were also called *Glain Neidyr*, from *glain* pure and holy, and *neidyr* a snake. It is curious to find these beads in the ancient British tombs, in the graves of our Roman conquerors, in the tumuli of the Anglo-Saxons, and at the present day in the Ashantee district of Africa; while a bead in all respects similar, is made in Venice.

VENETIAN GLASS. *Cases* 71, 72.—Venice, for a long period during the middle ages, was celebrated throughout Europe for its glass. Familiar with the manufacture from an early date, the Venetians, on the capture of Constantinople, in 1204, profited by their intercourse with the East, and glass factories soon became so numerous at Venice, that towards the latter part of the thirteenth century they were removed to the adjacent island of Murano. During the fourteenth century, the art was principally directed to the production of beads and other trifles, but a fresh impulse was given to the manufacture on the fall of the Eastern empire; and during the fifteenth and sixteenth centuries Venice produced those peculiar examples of glasswork, which, from their ingenuity of design and delicacy of execution,

acquired a wide reputation, and for a long time, defying imitation, enabled Venice to maintain a monopoly of the manufacture. The case No. 72 contains a fine collection of these skilful productions.

The *Vetro di trina* is a fine lacework, with intersecting lines of white enamel or of transparent glass, forming a series of diamond-shaped sections, the centre of each having an air bubble of uniform size; this glass was executed almost with the precision of engine lathe turning.

The art of making *frosted glass* appears to have been lost until it was revived at the Falcon Glass Works about 1850. Mr. Apsley Pellatt says: "Suddenly plunging hot glass into cold water produces crystalline convex fractures, with a polished exterior like Derbyshire spar, but the concave intervening fissures are caused, first by chilling and then reheating at the furnace, and simultaneously expanding the reheated ball of glass by blowing, thus separating the crystals from each other, and leaving open fissures between, which is done preparatory to forming vases or ornaments. Although frosted glass appears covered with fractures, it is perfectly sonorous." The ancient frosted glass is represented in *Case* 72; the modern in *Case* 52.

In making *filigree glass* canes of plain, coloured, or opaque white glass are arranged in a mould, and a solid ball of flint glass is then heated so that the canes of glass adhere to it; these are marvered or rubbed into a uniform mass, which is then covered with a gathering of white glass, and is formed into any shape.

"*The Venetian Ball*," says Mr. Pellatt, "is a collection of waste pieces of filigree glass conglomerated together without regular design; this is packed into a pocket of transparent glass, which is adhesively collapsed upon the interior mass by sucking up, and thus producing outward pressure of the atmosphere."

"*Millefiore* is more regular in design than the ball, but of the same character. It was formed by placing lozenges of glass, cut from the ends of coloured filigree canes, ranging them in regular or irregular devices, and encasing them in transparent glass."

Schmeltz Glass, the character of which may be seen in the specimens in Case No. 71, was formed by welding together variously tinted glasses until the colours become irregularly blended, and the mass assumed somewhat the appearance of a variegated marble.

The *Venetian Plate* and another specimen of opaque glass appear to resemble in many respects Réaumur's porcelain (p. 126).

Old German Glass, &c. *Case* 71.—This Case contains several interesting examples of early German glass. The tall cylindrical beakers, ornamented with escutcheons and other designs in opaque enamel colours, were peculiar to Germany during the

sixteenth and seventeenth centuries; and two of the specimens before us bear the date 1655. A smaller drinking glass, with a delicately executed painting in brown camaïeu, furnishes an example of the style of monochrome practised by the Germans in the seventeenth century.

Some specimens of old Dutch and French glass are also placed in this Case. On the upper shelf is a goblet of engraved glass, formerly used by Charles II. Through Sir Robert Gayer, one of his courtiers, it came into the possession of the Hodgson family.

Modern Ornamental Glass. *Cases* 66, 68.—Before passing to the strictly modern examples of glass-making, attention may be called to a few specimens of *old Bristol glass* arranged on the upper shelves in *Case* 68.

Much of the modern glass exhibited here was obtained from the Great Exhibition of 1851, and is noteworthy for its beauty of colour and elegance of decoration. The fine yellow on the specimens is produced by *silver;* the yellow of the ordinary glass may be produced by charcoal, iron or antimony.

Canary Yellow, or Uranium yellow, is the result of the combination of oxide of uranium with the flint glass. This glass has some peculiar optical properties. If we look *through* it the colour is purely yellow, but if we look *at* any surface of it upon which the light falls it appears green. This phenomenon, termed *fluorescence*, is possessed by uranium glass in common with many other bodies, such as a solution of sulphate of quinine, an infusion of horse-chestnut bark, and some varieties of fluor-spar.

The finest reds on the vases, &c., are produced by the *purple of Cassius*, which may be regarded as a stannate of tin with a stannate of gold; or by a solution of gold in *aqua regia* (*nitro-hydrochloric acid*). The ordinary red glass is produced by *copper*. The sub-oxide of copper (cuprous oxide) possesses a colouring power of remarkable intensity; hence glass is usually only coated or *flashed* with the red material.

Amethystine Glass is produced by the peroxide of manganese, and *blue* by means of cobalt. *Green Glass* is obtained by the use of iron, or preferably by cupric oxide.

Many examples of *flashing*, or spreading one colour upon another over white glass, are in these Cases. By cutting down through those layers to different depths, a very ornamental appearance can be produced.

Iridescent Glass may be prepared by heating the finished article in water containing hydrochloric acid, under pressure, or by exposing the heated glass to the vapour of stannous chloride.

Examples of modern imitations of *millefiore*, and improvements on the old Venetian work are shown, and a specimen exhibiting the manner in which the sections of canes are disposed previously to their being enclosed in a mass of transparent glass, accompanies the specimens. When these coloured canes

have been enclosed in a mass of glass the product can be readily formed into tazze or vases as shown in the finished examples in Case 66.

Some very fine examples of modern engraving on glass will also be found here. The ordinary tools used in engraving glass are discs of copper, smeared with oil and emery and worked by a lathe.

Attention may here be directed to the specimens of *Aventurine glass,* made at Murano and largely used in cheap jewellery. The brilliant laminæ are particles of metallic copper, showing under the microscope beautiful crystalline forms. Here, too, is a large series of *artificial gems* made of strass.

Strass , so called after its inventor, is a glass possessing in the highest degree purity and transparency, combined with the greatest possible lustre. It is a mixture of quartz, boracic acid, purified caustic potash, and a large proportion of oxide of lead, introduced in some specimens of strass as red lead, and in others as white lead. With perfectly pure and colourless strass, the colouring agent is combined — the following being a few examples:—

Topaz, antimony and gold; *Ruby,* purple of Cassius; *Emerald,* oxide of copper or chromium; *Sapphire,* oxide of cobalt ; *Amethyst,* cobalt and gold; *Beryl,* antimony and oxide of cobalt; *Garnet,* gold, antimony, and manganese ; *Opal,* bone ashes, oxide of uranium and forge scales, or, in some cases, oxide of nickel.—(*Knapp.*)

At an early period the practice of making hollow glass beads, and filling them with a pearly varnish, was adopted. *Artificial pearls* were thus made by some artists at Murano, but the government of Venice considered the invention too fraudulent and prohibited its practice.

A French bead maker, Jaquin, revived and improved the art. He observed that the bleak (*Cyprinus alburnus*) when washed in water gave off numerous fine silver-coloured particles which had the lustre of the most beautiful pearls. He consequently scraped off the scales of the fish and called the pearly powder which was diffused through the water, *essence d'orient,* or essence of pearl. At first he covered beads of gypsum with this, but as the ladies who wore them found the pearly powder left the beads and adhered to the skin the use of those ornaments fell off. The beads were then made of glass, a glass easily melted and made a little bluish, being drawn into tubes which were called *girasols* (the word signifying opal). From these tubes hollow globules were blown, and they were then covered on the inside with a solution of isinglass and the pearl essence, which was blown in warm and spread over the internal surface by rapid motion. When dry, the globules were filled with wax, bored through with a needle and strung as beads.

Enamels.

Table Cases 60 *and* 61. *Model of Tomb No.* 59.

Enamelling, or the process of covering metals or stones with a vitreous substance, or of running enamels into portions which have been previously removed by a graver, is of high antiquity.

A series of historical specimens illustrating this art will be found in Table Case 61. Commencing with some Roman enamels found near Eden in Cumberland, we have next a Byzantine enamel on gold of the 11th century, being a portion of the gold altar front obtained from Constantinople by the Doge Pietro Orseola. This is followed by a reliquary of the 13th century, enamelled in the style called *champ levé.* In this process those parts of the design intended to appear in enamel are hollowed out in the metal ground, leaving the outline in slender elevated partitions or bands of metal; the intaglio portions are then filled in with the coloured vitreous substance introduced in the state of powder and afterwards fused; the surface of the whole being finally smoothed by grinding and polishing.

The 14th century is illustrated by a priket candlestick from Dijon in champ-levé enamel, and a monstrance ornamented in a different style of enamelling, the design being here chased upon a silver plate, and the surface then covered with brilliant transparent enamels, through which the design appears. The 15th century is represented by an enamelled processional crucifix from Italy, and from this we pass to the much admired *Limoges enamels* of the 16th century. These are painted enamels of considerable merit, usually executed *en grisaille* on a dark ground, and relieved by the introduction of flesh tints and touches of gold; the works of the later artists are, however, frequently coloured, as seen in the polychrome enamels of the 17th century here exhibited. From the painting of enamel pictures, the art was extended to the decoration of metallic vases and other ornamental objects, of which the enamelled tazza in this case is an example. Among the Limoges enamels will be found works by Limousin, Raymond, Nouaillier, Laudin, and the master I. M. From the coloured enamels of Limoges we advance to what may be termed the enamel painting of modern times.

Enamel painting—properly, painting on enamel—is fully illustrated in *Case* 60. The white cake enamel used as the painting ground, and the beads and pipe employed as a flux, are all manufactured in Venice. These appear to consist of about ten parts of lead and three parts of tin, converted into oxide by heat and exposure; to the mixed oxides are added ten parts of quartz and two parts of common salt, and the whole fused together. The enamel being reduced to powder is spread over a plate of copper or gold and exposed to a strong heat;

the enamelled plate is then coated with flux, and again fired and ground down as shown in the specimens. This is the surface upon which the enameller has to work. He mixes metallic oxides with the flux, and with this mixture paints his picture. An enamel painting has to pass many times through the fire, consequently great care is required in this part of the work.

Mr. Hone was probably the first who ventured to paint large enamels; a small work by this artist, of the date 1749, is in this Case. Mr. H. Bone, R.A., by whom there are several beautiful works, exceeded all before him in the size of enamel paintings, his Bacchus and Ariadne, the original of which is in the National Gallery, measuring 18 inches by 16½. The portrait of Sir Henry De la Beche was painted on enamel from the life by the late Mr. H. P. Bone, and presented by him to the Museum.

The modern French Limoges enamels, and another enamel with the portrait of the celebrated Saussure, by Constantin, painted in 1845, will show the state of this art on the continent.

Model of the Tomb of William de Vallence (No. 59).--William de Vallence, senior Earl of Pembroke, half brother to Henry III., died in 1304, and was buried in Westminster Abbey. His tomb was decorated in the costly style of the period. Not only were the portions of the original enamelled, which are copied in the model, but that part also which is here represented in wood appears to have been covered over with brass plates richly enamelled. The figure in the model is of brass, cast by Mr. Beattie, and gilt by the electrotype process; the enamelling by Robert Ainger, and the base of Caen stone by H. C. Smith, the whole having been constructed under the superintendence of the late Mr. Albert Way.

Chinese and Japanese Enamels, Glass, &c.—In *Case* 55, on the eastern side, will be found some specimens illustrating the art of enamelling amongst the Chinese. From a very early period this nation has been in the possession of the art of enamelling metals, and of painting on enamelled surfaces. The large plaque and the bowl are examples of ancient *cloisonné* enamelling, differing from the champ-levé process already described, inasmuch as the outline is here formed, not of the plate itself, but of separate narrow bands of metal bent into the required shape, and attached to the ground. These incrusted enamels are accompanied by several examples of superficial enamelling; and with these are associated various specimens of Chinese pottery and glass. There are also exhibited here some examples of Japanese enamelling, including cloisonné work on porcelain, an art which of late years has been largely used in works exported to Europe.

Mosaics. *Table Case* 56.

Portrait of the Emperor of Russia, &c., on Gallery stairs, eastern side. Head of Christ, &c., on western side.

In this Case are some examples of ancient Roman tesselated pavements, which show the manner in which they were constructed, and the kind of design which is usually found. A portion of a mosaic pavement found at Halicarnassus is mounted on the western staircase.

The art of manufacturing glass mosaics was practised in old Rome, and the modern city is still the seat of this manufacture. The manufacture has, however, as might be expected, varied somewhat in character. As at present practised, thin rods of easily fusible glass of every variety of colour are prepared for the purpose. From masses of coloured glass are formed, first, slabs, and then the little rods exhibited; the artist softens these in the flame of his lamp, draws out the rod into a thick thread, and breaks off a piece of the thickness of the intended picture. The design of the picture is copied from a cartoon, and the pieces are placed in proper order on a sheet of copper, covered with a cement which serves for fixing the picture; when the whole slab is covered, the surface, which is uneven and unsightly from the unequal lengths of the rods, is ground and polished. After the removal of the polishing powder the interstices between the rods are filled with wax, which corresponds in colour with the different parts of the picture. Glass mosaics are now also manufactured in Venice. A large example of Byzantine mosaic is the Head of Christ, on the western staircase: whilst on the opposite side are two modern Roman mosaics, of large size, one being a portrait of the Emperor of Russia: this work was executed in 1828, and presented to the Museum by the Cavaliere Barbieri of Rome.

THE MODEL ROOMS.

The Model Rooms are situated at the northern or Piccadilly end of the building, and comprise an eastern and a western room on the Principal Floor, marked respectively A and B. The first room (A.), which opens directly on to the Principal Floor, contains a number of geological and mining models, principally illustrating *metal mining;* whilst the second room (B.) is practically devoted to models and machinery, illustrating work in our *coal mines.* Considerable changes have recently been made in the arrangement of the objects in these rooms, and as other changes are still pending, it is needless to enter into any detailed description of this department of the Museum.

Many of the mining models, formerly exhibited here, have been transferred to the Southern Galleries of the South Kensington Museum.

At the entrance to Room A. are suspended two *maps of Scotland,* one physical and the other geological ; whilst to the left of the visitor, on entering, is a Wall Case containing some fine examples of *Veinstones* and a series of diagrams illustrating the occurrence of ore-deposits.

To the right of the visitor, as he enters the room, is a range of Wall Cases containing a number of exceptionally large *mineral specimens,* occurring mostly as veinstones. Here, too, is placed temporarily a large map illustrating the *Geology of the Thames Basin.* This map, composed of several sheets of the one-inch Geological Survey Map, was prepared for and used by the Royal Commission on Metropolitan Water Supply, 1893.

In the centre of the room stands a Case devoted to a large model of the workings at an *Australian gold mine.* It represents the works of the Clunes and Port Philip Mining Companies, in Victoria, as they appeared about the year 1858, and shows picturesquely the various operations of raising and crushing the gold-quartz and extracting the metal. An adjacent Case contains a *model of Holmbush Mine,* near Callington in Cornwall, ingeniously constructed by the late Mr. T. B. Jordan, so as to show the directions of the copper and lead lodes, and the details of the underground workings. The lower part of the Australian Case is occupied by a huge *crystal of Canadian Mica,* and by some samples of *auriferous gravels* from Australia ; whilst in the lower part of the Holmbush case will be found a *model of a Swiss Glacier* by Professor Heim, of Zurich.

Two models of *salt mines* in the Salzburg Alps are placed among the models in the central area of this Room. The method

of obtaining the salt is simple enough. Fresh water is introduced into a subterranean excavation in the saliferous deposit, and the salt is thereby dissolved out from the gypseous marl, forming a brine, which is conducted by means of pipes to the evaporation works.

Several geological and topographical Models are also placed in the centre of the room. One of the most interesting of these is a geological *model of the Isle of Arran,* constructed by the late Sir Andrew Ramsay, when a young man unknown to science, and exhibited by him at the Glasgow meeting of the British Association in 1840. A geological *model of Arthur's Seat,* Edinburgh, will also be found here. In the front of the fireplace, and under a screen of *wire ropes* on the wall at the end of the room, stands a large Model showing the geological structure of part of the south coast of the *Isle of Wight,* stretching from Bonchurch to Sandown Bay, and illustrating the nature of the Undercliff. With this model may be studied another, representing the coast between Sandown Bay and Whitecliff Bay, showing the Chalk in an almost vertical position, with the overlying Tertiary series: both models of the Isle of Wight were constructed by the late Captain Boscawen Ibbetson. A geological *model of Mont Blanc,* and a topographical *model of the Alps and the Plains of Lombardy,* presented by the late Dr. Fitton, are also placed here; while near the end of the room stands a model, showing the *great landslip at Axmouth,* in South Devon, which occurred on Christmas Day 1839, and was described by Conybeare and Buckland. At the base of this is a small model, by Mr. T. Gibb, representing a *peat-moss in Lanarkshire,* which slipped in August, 1861.

Along the Northern Wall of this Room, under the range of of windows looking on to Piccadilly is a series of Cases containing *tools employed in various mining districts.* Near the entrance to Room B. is a case devoted to tools employed by the colliers in the North of England. Close to this stands a case of tools used by the metal miners of Cornwall. The next Case is appropriated to Saxon tools, and the succeeding case to the tools used in the lead mines of Debyshire and Flintshire. These are followed by a series of Mexican tools, and these in turn by examples of tools employed in the collieries of South Wales. Then follows a case containing mining tools used in Flintshire, and also a set of Russian tools. Finally, there is a Case devoted to the tools used at Schemnitz, in Hungary, where the mines yield ores of gold, silver, lead and copper.

From the Eastern Model Room, the visitor enters the second apartment (B.), which is devoted chiefly to illustrations of colliery workings. Immediately facing the entrance is a model representing the *physical features of a coal district,* showing the outcrop of the beds of coal, and how they are affected by faults or troubles. Next to this stands a model representing part of the *lead-mining district of Alston Moor,* in Cumberland;

and close by a *model of the Forest of Dean*, both by the late Mr. Thomas Sopwith. On the latter model the *outcrops* or *basseting* of the principal beds of coal are shown on the surface, and vertical sections of the strata are painted on the sides of the model. In order to show similar vertical sections in the interior of the Forest, the model is made in compartments, placed on a sliding table, so as to be easily separated.* A Case containing samples of coal, ironstone, and other products of the Forest of Dean, stands near the fireplace.

On the right hand of the visitor on entering the room is another of Mr. Sopwith's ingenious models, representing the *Ebbw Vale and Sirhowy Iron Works in the county of Monmouth.* Opposite to this on the left of the visitor will be found a large Case, in course of arrangement, containing a series of specimens illustrating the different *varieties of Coal* and allied substances. At the back of this Case, against the adjacent wall, is a natural section of the *coal-measures at the Rosebridge pits near Wigan*, at one time the deepest in this country. By the side of this section is a fine *specimen of the Better-bed coal* of Bradford in Yorkshire, showing the entire thickness of the bed, and the character of the adjacent strata. The "better-bed" coal is interesting for exhibiting under the microscope vast numbers of the spores of coal-measure plants.

A great part of the central area of the room is occupied by two large *models of Shipley Colliery, in Derbyshire* (G. 1 and 2), exhibited at the International Exhibition of 1862, and afterwards presented by Messrs. Woodhouse and Jeffcock. From these models an excellent idea may be obtained, not only of the surface arrangements of a large colliery, but also of the underground workings. G. 1 shows the method of working the coal and the course of the ventilating currents, whilst G. 2 exhibits the winding machinery at the surface, with its steam engine, &c.

Over the fire-place is a large screen bearing a number of *ancient processional tools* from Saxony. It is interesting to note how the several parts of a timberman's axe have become conventionalised and rendered useless in these ornamental tools.

On the right side of the fire-place are two *natural sections*, one of the coal seams near Barnsley, the other of ironstone deposits in North Lincolnshire.

In the front of the fire-place is one of Blake's *stone-breakers*; whilst on the wall beneath the windows of this room is a long range of Glass Cases which formerly contained mining

* It is important, to avoid injury, that the models should not be touched, except by persons acquainted with them. For any special purposes, permission to examine this and other models minutely may be obtained, but *the public are especially requested not to attempt to open the models.*

models, but are now temporarily occupied by *statistical diagrams* bearing on our coal production, and by some large slabs of stone showing *ripple-marks*, &c.

Against the opposite wall is arranged a large collection of *miners' safety lamps*, transferred to the Museum by the Royal Commission on Accidents in Mines, under the chairmanship of the late Sir Warington Smyth. The collection includes most of the lamps which were practically tested by the Commissioners and referred to in their Report.

In order to reach the Galleries the visitor should ascend the spiral staircase in the north-east corner of the first Model Room A. The arrangement of the Galleries is at present in a transitional condition—a remark which is applicable to the Model Rooms generally; and hence the notice of the present condition of this section of the Museum need be but brief. In the Gallery of Room A., the Wall Cases are devoted to the display of a series of large specimens showing the successive stages in *the manufacture of crown and sheet glass*, with examples of the workmen's tools. The Cases on the balustrade of the Gallery contain, at present, a series of Sopwith's *models illustrating geological phenomena*, and some miscellaneous mining instruments. At the western end of this Gallery is a Glass Case filled with a large series of *crystallographic models* in wood and glass; and there is also a small set of Mr. Jordan's models in coloured cardboard.

On passing to the Gallery of Room B. the visitor finds the Wall Cases on his left hand devoted to a large series of specimens, in course of arrangement, illustrating *the use of clays in the manufacture of bricks*. With these will be found a collection of *fire-bricks* and *crucibles*, illustrating the use of highly refractory materials, like the Stourbridge fire-clay. The fire-clays are commonly supposed to represent the exhausted soils of the coal-measure forests. A *Bath brick* is here exhibited by the side of a sample of the siliceous silt of the River Parret, from which such bricks are made at Bridgewater in Somersetshire. The bricks are said to be named after a Mr. Bath, who originally made them. There is also shown here a specimen of *diatomite*, or diatomaceous deposit from the bed of a lake in Skye. This material consists of the minute siliceous cases (frustules) of the unicellular algæ known as diatoms, and is employed as a refractory material for fire-proof structures, and has been used, as an absorbent for nitro-glycerine in the preparation of dynamite.

The Cases on the Gallery-balustrade contain an extensive collection of *mineral phosphates*, presented recently by Mr. Hoyer Millar, and a series illustrating the *varieties and uses of borax*, collected by Mr. Fleming, and referred to in a paper which he read before the Society of Arts in 1891.

GALLERIES.

The two Galleries, called respectively the Lower and the Upper, are devoted to the exhibition of an extensive collection of British Fossils, obtained for the most part during the progress of the Geological Survey. The fossils are exhibited partly in a series of Wall Cases and partly in the small Flat Cases resting on the balustrade of the Galleries. It should be explained that under the Flat Cases are glass-topped drawers, which add greatly to the available space, and may be pulled out by the visitor desirous of inspecting the specimens which they contain. In the following description the Flat-Cases are distinguished by numbers in thin type (1), and the Wall Cases by thick type (**1**). In examining the Wall Cases it should be noticed that the numbering, unlike that of the minerals and rock specimens, proceeds from the *lower* part of the cases, the bottom shelf being always regarded as the first. The upper parts of the Wall Cases, too high for the convenient display of specimens, are appropriated to a series of diagrams of Fossils.

The study of Fossils is termed *Palæontology*, or the science of ancient life, the name being derived from the Greek, *palaios*, ancient; *onta*, beings; and *logos*, a discourse.

To assist the student of palæontology, who will probably at first find so large a collection rather bewildering, the characteristic fossils in each formation are indicated by red spots. The green spots seen here and there on certain fossils indicate that the specimens so marked have been figured.

The fossils are arranged in stratigraphical sequence, commencing with the organic remains found in the oldest fossil-bearing rocks, and thence gradually proceeding in ascending order to the forms of life in the most recent strata. In order to facilitate the study of the collection, the following Table, showing the main groups recognised by the Geological Survey, may be useful (p. 140). A diagrammatic table of strata is also placed in each Gallery, and a more comprehensive one will be found in the Rock Room.

In this scheme of classification the oldest known rocks are placed at the bottom, and the succeeding groups of stratified fossiliferous rocks pass upwards in regular ascending order. A similar plan is adopted in the arrangement of the fossils. The oldest British fossils will be found at the south-west end of the Lower Gallery, whence the series ascends in stratigraphical order, and terminates in the south-west corner of the Upper Gallery. It should be noted, however, that the fossil *vertebrata*, or back-boned animals, form a distinct series, not conforming to the stratigraphical arrangement, but occupying the Recesses in the two Galleries.

Table of British Strata.

	Quaternary or Post-tertiary.	*Recent.* *Pleistocene.* *
	Tertiary or Cænozoic.†	*Pliocene.*‡ (Cromer Forest bed and Crags.) *Oligocene.*§ (Fluvio-marine beds of the Hampshire basin.) *Eocene.*‖ (Bagshot series, London Clay and Lower London Tertiaries.)
	Secondary or Mesozoic.¶	*Cretaceous.*** (Chalk, Upper Greensand, Gault, Lower Greensand, Wealden series.) *Jurassic.*†† (Purbeck and Portland series, Kimeridge clay, Corallian series, Oxford clay, Great Oolite series, Inferior Oolite, Lias.) *Triassic.*‡‡ (Rhætic,§§ Keuper,‖‖ Bunter.¶¶)
Primary.	Palæozoic***	*Permian.*††† *Carboniferous.* *Devonian* and Old Red Sandstone. *Silurian.*‡‡‡ *Cambrian.*
	Pre-Cambrian, or Archæan.§§§	

---

* *Pleistocene*, Gr. *pleistos*, most; *kainos*, recent.

† *Cænozoic*, Gr. *kainos*, recent; *zoe*, life. ‡ *Pliocene*, Gr. *pleion*, more.

§ *Oligocene*, Gr. *oligos*, few.

‖ *Eocene*, Gr. *eos*, dawn. Most of the names of the groups of tertiary strata were given by Lyell to indicate the proportion of recent to extinct species of mollusca which they respectively contain. No *miocene* (Gr. *meion*, less), rocks are now recognized in Britain. The oligocene group was named by Beyrich, of Berlin.

¶ *Mesozoic*, Gr. *mesos*, middle.

** *Cretaceous*, Lat. *creta*, Chalk.

†† *Jurassic*, from the Jura Mountains.

‡‡ *Triassic*, from its threefold character in Germany.

§§ *Rhætic*, from the Rhætic Alps.

‖‖ *Keuper*, Ger. quarryman's term, from local name of a checked fabric.

¶¶ *Bunter*, Ger. "variegated."

*** *Palæozoic*, Gr. *palaios*, old.

††† *Permian*, from Perm in Russia.

‡‡‡ *Silurian* from the British tribe of Silures. Prof. Lapworth's term *Ordovician*, from the tribe of the Ordovices, is often used to indicate certain strata regarded by some as intermediate between the Silurian and the Cambrian.

§§§ *Archæan*, Gr. *archaios*, ancient.

Whilst the general arrangement of the fossils is stratigraphical, there is under each formation a subordinate zoological classification of the invertebrata, commencing with the simpler forms of life.

THE LOWER GALLERY.

This Gallery contains the fossil plants and invertebrata of the palæozoic strata, and also, the pleistocene vertebrates. The latter have been placed here, in consequence of the difficulty of finding space for them with the pleistocene invertebrata on the floor above. The general series of fossils may be conveniently studied by commencing with the Flat Cases on the Gallery-rail at the head of the western staircase.

Against the opposite wall is placed a polished block of serpentinous limestone from the Laurentian rocks of Canada, containing the curious structure called *Eozoon.* This has been regarded by some authorities as a gigantic reef-forming foraminifer of peculiar interest, as representing the oldest known form of life. Its organic nature, however, is now usually denied. There is still some uncertainty respecting the true organic grade of the branched structures termed *Oldhamia* which occur in Cambrian rocks near Dublin and rank among the most ancient traces of life yet found in the British Isles. Worm-burrows and castings are met with in these and in many other ancient rocks, as in the Longmynd rocks of Shropshire, and notably in the Cambrian quartzites and limestones of the north-west of Scotland.

Among the oldest organic remains, often fragmentary and ill-preserved, are those of the extinct crustaceans well known as *Trilobites.* Numerous examples will be found in the Flat Cases, serving to illustrate their great diversity in size, shape and structure. The Cambrian strata have, in recent years, been arranged in zones, named, according to their typical trilobites, the *Olenellus*, the *Paradoxides*, and the *Olenus* zones. A conspicuous fossil in the first Flat Case is the large *Paradoxides Davidis* from the Menevian beds—a group of beds which borrow their designation from *Menævia*, the classical name of St. David's.

The Lingula flags, which occur above the Menevian beds, derive their name from the little brachiopod called *Lingulella Davisii*, closely akin to *Lingula.* This type is remarkably persistent, the horny shell of the living lingula being extremely similar to the Cambrian fossil. The brachiopods, comparatively rare at the present day, are a group of great importance in the Palæozoic and Secondary strata. The Lingula flags are followed by the Tremadoc beds, so named from the locality in North Wales where they are characteristically developed. The *Angelina Sedgwickii*, from these slates, is a trilobite notable for the distortion which it has, in many cases, suffered by earth-pressure.

In the drawers below the Flat Cases will be found, among other specimens, a collection of fossils from the Durness limestone, in Sutherlandshire, including chambered shells of cephalopods, like *Orthoceratites.* The lower and middle parts of this limestone are of Cambrian age, but the higher members may be Lower Silurian.

The *Silurian System,* named by Murchison from the ancient British tribe of the Silures, may be divided into a lower and an upper group of beds. The Lower Silurian group includes the Arenig, the Llandeilo, and the Bala beds—three divisions named respectively from the Arenig Mountains, from Llandeilo in Carmarthenshire, and from Bala in Merionethshire. Lower Silurian fossils occupy a large number of Flat Cases. Here will be seen the noble trilobite *Ogygia Buchii,* from the Llandeilo flags, and also some large species of *Asaphus.* The term Caradoc beds, used on many of the labels, is borrowed from Caer Caradoc, in Shropshire, where shelly sandstones occur approximately of the same age as the Bala limestone. Many of the Caradoc specimens show numerous casts of the shells of brachiopods.

Of all fossils in these Lower Silurian formations the most characteristic are the curiously serrated bodies called *Graptolites* by Linnæus,—(*grapho,* I write, and *lithos,* a stone)—from the fanciful resemblance of their remains in the stone to quill pens with the feathers cut. In Wall Case **4** are some excellent examples of these fossils, especially from the Llandeilo shales; whilst a large diagram above illustrates their structure and suggests their relationship with the living sertularians. Graptolites occur throughout the Silurian system, and many of them, having a very limited geological range, are useful as characteristic fossils of particular zones.

The fauna of the Upper Silurian rocks—including the Llandovery, Wenlock and Ludlow groups—is well represented in Wall Cases **6** to **10**, and Flat Cases 13 to 28. The Wenlock limestone of Dudley is marvellously rich, and many fossil-crowded slabs are shown in Wall Case **8**. The fossils include corals,—both simple forms, or those growing singly, like *Omphyma,* and composite forms, or those aggregated in reef-like masses, such as *Favosites, Cyathophyllum,* and the curious "chain coral" called *Halysites.* Some thin sections of coral are here mounted as transparent objects. Here, too, are many of the Wenlock crinoids, or "stone lilies," each composed of a long-jointed flexible column supporting a cup with the rim surrounded by a number of long fringed arms. Some large slabs of Wenlock shale are notable for their fine examples of *Actinocrinus.* The Wenlock trilobites, in the Flat Cases, are remarkably fine and well preserved, and attention may be specially called to the large examples of *Homalonotus* and to the fine specimens of *Calymene Blumenbachii,* known as the "Dudley locust." Many of the trilobites were capable of rolling themselves up into a ball, like

the common woodlouse, and examples of these rolled-up fossils will be found in the collection.

The visitor is not likely to overlook the large specimens of *Pentamerus Knightii*, a characteristic brachiopod of the Aymestry limestone.

Some specimens of the Ludlow and Old Red Sandstone Crustaceans, such as *Eurypterus* and *Pterygotus*, will be found in Wall Case **10**. A cast of a remarkably fine *Pterygotus*, from Scotland, showing the perfect form of this gigantic crustacean, is in a glass case against the wall in Recess No. 18.

The earliest known relics of vertebrate life in the British rocks occur in the Ludlow series. Even in the Lower Ludlow beds remains of fishes have been detected, but in the Upper Ludlow group they become abundant, though fragmentary. Examples of these fishes, the precursors of those which abounded in the Old Red Sandstone period, will be found in Wall Case **16**.

The fossils of the Old Red Sandstone and Devonian strata receive ample illustration in Wall Cases **10** and **11**, as well as in the Flat Cases 29 to 35. The Devonian system comprises all the marine strata in the south-west of England between the Silurian and Carboniferous systems. It is especially in the limestones of the Middle Devonian group, near Torquay, that fossils occur. The Great Devon Limestone is rich in corals, some of which appear to have grown in reefs, and a large suite of polished specimens will be found partly in the Wall Cases and partly in a Table Case(C), in the Recess No. 16.

From the Old Red Sandstone, which consists of strata deposited in inland waters, few fossils have been obtained, excepting the remains of fishes. The remarkable fishes, protected with bony plates and strange head-bucklers, are represented by such forms as *Cephalaspis* and *Pterichthys*, principally from Scotland. Most of the Old Red Sandstone fishes belong to the group of ganoids, of which the bony pike of the North American rivers is a good modern example. Ganoid fishes though now limited to a very few species, were richly represented in the waters of the Old Red Sandstone. Some large blocks of the sandstone of Dura Den, in Fife, densely crowded with the remains of *Holoptychius*, will attract the eye by the contrast of the black fossils with the yellow matrix. The *Dipterus* of the Old Red Sandstone is interesting, as being allied to certain amphibious fishes, capable of breathing either atmospheric air or air dissolved in water, represented at the present day by such gill-bearing and lung-bearing forms as the *Ceratodus* of Queensland. As illustrating the land vegetation of the Old Red Sandstone period, attention should be given to the fine fronds of *Palæopteris* (*Adiantites*), from Kiltorcan in Kilkenny, an example of which is placed near the eastern staircase.

Above the Devonian and Old Red rocks come the beds forming the Carboniferous system. This is a great series of

shales, sandstones, limestones, ironstones, and coal seams, many of the beds being extremely rich in organic remains. The Flat Cases 36 to 49 are devoted to carboniferous fossils, among which the brachiopods are especially conspicuous; many of the specimens of *Productus* and of *Spirifera* from the Carboniferous Limestone being exceptional for size and beauty of preservation. The trilobites, on the other hand, are but small and of few genera, the tribe being evidently on the eve of extinction. In Wall Case **12** is a large suite of beautiful corals and crinoids, illustrating most of the forms with which the Carboniferous Limestone is, in many localities, crowded. A Table Case (D), in Recess No. 17, contains also a fine series of polished corals from the Carboniferous Limestone near Bristol. The Cephalopods in Wall Case **13** are of much interest, including such forms as the straight-chambered shell termed *Orthoceras*, the familiar genus *Nautilus*, still living, and the nautiloid shell, with zigzagged sutures, called *Goniatites*. Near the eastern staircase is a gigantic *Orthoceras*, nearly six feet in length, from the Carboniferous Limestone of Holy Island, off the coast of Northumberland.

Attention will be attracted, as the visitor passes the Wall Cases **14** and **15**, by the large series of plant-remains, representing the terrestrial vegetation of the coal-measures. The principal types of the carboniferous flora are referable to flowerless plants, and include numerous genera of ferns; plants allied to the horse-tails, but of larger growth, such as the *Calamites;* and those which, though in many cases of gigantic size, find their nearest modern representatives in the humble club-mosses; such are the well-known fossils called *Lepidodendron* and *Sigillaria*, with their roots or rhizomes termed *Stigmaria*, and the spore-bearing cones known as *Lepidostrobi*.

In the Wall Cases placed in the Recesses 16 to 18 are numerous specimens illustrating the carboniferous vertebrata, and including the teeth and spines of various fishes, especially sharks, from the Carboniferous Limestone. The large *Rhizodus*, a ganoid from the coal-measures, is especially noteworthy, one of its teeth, here exhibited, measuring as much as five inches in length. It is in the coal-measures that we find the earliest examples of those vertebrata, which, during part of their life, must have been exclusively air-breathers. The *Anthracosaurus* and *Loxomma* are examples of such forms. These are all known as Labyrinthodonts—so called from the curious structure of certain teeth as displayed in microscopic sections. They belonged to the class Amphibia, which contains the frogs, toads, and newts, and which may be separated from the Reptiles by having respiration effected in early life by means of gills.

The Permian system, which overlies the Carboniferous, and is usually regarded as marking the upper limit of the Palæozoic strata, has its fauna illustrated chiefly in Table Cases 50 and 51.

The shells, mostly small and in some cases distorted, are from the Magnesian Limestone: whilst the fishes, such as the ganoid

Palæoniscus, shown in the Wall Cases of Recess 18, occur in the Marl-slate of Durham.

THE UPPER GALLERY.

In order to study the fossils of the Secondary or Mesozoic strata, the visitor should pass to the Upper Gallery by the western staircase. Before examining the fossils he may notice three small Scroll Brackets, springing from the Table Cases of the Gallery, which support glass shades covering miniature representations of the three planets—Mercury, Venus, and the Earth, with her satellite, the Moon. These are placed at true relative distances from the large gilt globe, representing the Sun, which is a conspicuous object at the end of the Gallery, over the door leading to the Rock Room. A *glycerine barometer,* by Mr. J. B. Jordan, will be found in Recess 1.

Turning to the fossils the visitor may commence with those of the *Trias,* or New Red Sandstone—a formation which lies at the base of the Secondary series, but offers in this country only few fossils. Some Triassic plants and invertebrata are placed in the lower part of Wall Case **4**; whilst an interesting collection of reptilian remains from the Elgin sandstone, believed to be partly of Triassic age,i s displayed in the Table Case which stands in the Recess No. 3. The reptiles include the crocodilian *Stagonolepis,* the little lizard *Telerpeton,* the peculiar horned reptile described by Mr. E. T. Newton, as *Elginia,* and the dicynodont genera named by him *Gordonia* and *Geikia.* Most of these are represented by casts, but some of the sandstone originals, showing hollow moulds of the bones, are also exhibited.

The *Rhætic beds,* which furnish a transition from the Trias to the Lias, are represented by a small series of fossils in Wall Case **3** and in the drawers of Table Case (A), as well as by some of the remarkable teeth of *Ceratodus* in a Case in the Recess numbered 2.

Occurring in extraordinary abundance, and in an excellent state of preservation, the fossils of the Liassic and Oolitic formations necessarily demand a large amount of space. The group of Liassic rocks, forming the lowest member, is represented in Flat Cases 1 to 7, and in Wall Cases **4**, **5**, and **6**.

The extinct cephalopods, well known as *Ammonites,* are abundantly represented in the Wall Cases, as also in a Table Case (A), in Recess No. 2; whilst some of the larger forms are exhibited at the head of the staircase. The equally well-known *Belemnites* (Greek *belemnon,* "a dart") are the hard internal supports of cephalopods, akin to the cuttle-fishes and calamaries. In some of the allied forms, like *Geoteuthis,* the ink-sac, with its indurated pigment, is well preserved. Some fine examples of Liassic fish and reptilian remains are in the Recesses 1, 2, and 3. The type-specimen of *Hybodus de la Bechei* is in No. 1; and the head of a large *Pachycormus* is also noteworthy. The reptilia are represented by specimens of the *Ichthyosaurus* and *Plesiosaurus.*

At the head of the staircase, on the western side, are some remains of *Ichthyosaurus,* including a fine specimen from the Lower Lias of Street, in Somersetshire ; and on the stairs of the eastern side, a *Plesiosaurus* from the same locality. The ichthyosaurus was a gigantic reptile of aquatic habit, furnished with a vertical tail, and with paddles resembling those of the whale, while it is known that some species had a triangular dorsal fin. It was a creature of great size, some specimens attaining to upwards of 24 feet in length. The plesiosaurus is another extinct aquatic reptile of large size, and furnished with paddles resembling those of the ichthyosaurus, from which it differed however in general form, its most distinctive characters being found in its comparatively small head and long neck. A head of *Teleosaurus,* a crocodilian form, resembling the recent gavial of the Ganges, is placed in Recess No. 3.

A rich collection of Oolitic mollusca, excluding cephalopods, will be found in the Flat Cases 8 to 31, and the remaining invertebrates, including the corals, crinoids, sea-urchins, star-fishes, cephalopods and crustacea, in Wall Cases **7** to **10**. At the head of the western stairs is a Case (C), specially devoted to the fine collection of *Oolitic Trigonias,* made by the late Dr. Lycett. Some well-preserved plant-remains from the Inferior Oolite, near Scarborough, principally ferns and cycads, are in Wall Case **7**, while the Purbeck cycad-stems, known to quarrymen as " birds' nests," are in the lower part of the large Case (C) at the top of the staircase. The largest of all the Ammonites—*Ammonites giganteus*—from the Portland beds, is represented by specimens near the stairs. The vertebrata of the Oolites are placed with those of the Lias—the two formations being often united under the name of the *Jurassic system*—in the Recesses 2 and 3. The remains of turtles from the Purbeck beds are here noteworthy ; but even more interesting are the mammalian relics, among which attention may be specially called to the unique specimen of *Stereognathus* from the Stonesfield Slate, and the beautifully preserved jaw of *Triconodon,* from the Purbeck beds, presented by Mr. Henry Willett.

The fossils of the Wealden beds, which are of fresh-water origin, find illustration in the Flat Cases 33 and 34, and the Wall Cases **3** and **10**. They include the remains of plants, mollusca, crustacea, fishes, and reptiles. Among the reptilian relics the most notable are those of the gigantic dinosaurs (Gr. *deinos,* terrible), of which *Iguanodon* is the type.

The marine beds of the Lower Greensand, the Gault, and the Upper Greensand, have yielded a rich fossil fauna, amply illustrated in the Wall Cases **11** and **12**, and in the Flat Cases 34 to 49. It is not unusual to associate the Lower Greensand with the Wealden beds, under the name of the Neocomian group—a name borrowed from the Latinised form of Neuchatel (*Neocomum*). Of all these Lower Cretaceous fossils, the most attractive, by the perfection of their preservation, are those of

the Gault. Some of the Gault ammonites in Wall Case **11** still retain much of the original iridescence of their pearly shells. Attention may be here directed to the fine suite of fossils from the Greensand of Blackdown, in Devonshire, where the shells are preserved in chalcedonic silica, and to the fossils from the so-called Upper Greensand of Cambridge, where numerous derived fossils, rolled and fragmentary, occur in the workings for phosphatic nodules, improperly called "coprolites," at the base of the chalk.

The fossils of the Chalk naturally claim, by their variety and beauty, a large space. Most of the mollusca are in the Flat Cases 50 to 54, while the sponges, echinoderms, cephalopods, crustacea, &c., are displayed in Wall Cases **13** and **14**. Many of the large cretaceous ammonites are mounted in a glass case at the top of the stairs; whilst a selection of cretaceous sponges is displayed in a Case (D) at the head of the staircase, where also will be found the Lycett collection of *Cretaceous Trigonias*. The vertebrata from the cretaceous rocks, including many interesting specimens of chalk fishes, are exhibited partly in the Wall Cases of Recess No. 3, and partly in an adjacent Table Case (E). The latter contains some beautiful examples of the crushing teeth of *Ptychodus*, a characteristic fish of the chalk seas, allied to the living Port Jackson shark, and having the floor and roof of the mouth covered with these teeth, as with a tesselated pavement. A case between the Recesses 15 and 16 contains a large series of Upper Greensand sponges, mounted in the positions in which they probably grew on the floor of the cretaceous sea.

All the southern end of the Gallery is given up to illustrations of tertiary palæontology. The beautiful Eocene mollusca will be found in the Flat Cases 54 to 56 and in the drawers below. Among the Eocene mollusca may be noted the marine fossils of the Thanet beds, the estuarine and fresh-water shells of the Woolwich and Reading series, and the marine mollusca of the London clay and of the Bracklesham and Barton beds. The gigantic *Cerithiums*, from the Bracklesham series, are conspicuous objects in Case 58. The fluvio-marine fauna of the Oligocene beds of the Hampshire coast and the Isle of Wight is represented in Flat Cases 61 to 63.

Turning to the Wall Cases we find Eocene fossils occupying the greater part of Nos. **18** to **20**. Especially noteworthy are the specimens of *Nautilus* from the London clay, with the pearly lustre still perfect; the numerous crustacean remains, more or less resembling the crabs and lobsters of the present day; the plant-remains from Sheppey, chiefly nuts resembling those of the nipa palm, abundant in parts of India, the Philipines and the Moluccas; and the masses of wood, bored by the teredo, by no means uncommon in the London clay. Some plant-remains from the Bagshot leaf-beds of Alum Bay and Bournemouth are also exhibited in these cases, where likewise will

be found many illustrations of the rich flora preserved in the clays and lignites of Bovey Tracey in Devonshire, including examples of the *Sequoia*, allied to the mammoth trees of California. These deposits were formerly regarded as of Miocene age, but it seems probable that no strata strictly referable to that period occur in Britain.

The Pliocene series, represented hiefly by the Crags, or shelly sands of East Anglia, receive ample illustration in Wall Cases **20** to **23**. Even a casual observer will not fail to notice such specimens as the large crab from Aldborough in Case 20; the handsome *Cassidaria* and the fine *Cyprinas* in Case 21; or the noble *Volutes* in Case 23. In Case 23 will also be found an interesting series of plant-remains and mollusca from the Forest-bed of Norfolk and Suffolk; whilst the succeeding Cases, 24 and 25, are devoted to Pleistocene fossils, including land, fresh-water and marine mollusca, with crustacea and echinoderms.

A rich collection of *Tertiary vertebrata* is exhibited in the recesses on the eastern side of the Upper Gallery. Commencing with Recess Case 15, the visitor finds himself in front of a group of Eocene fossils, chiefly the remains of fishes, and including representatives of the sharks, rays, chimæroids, ganoids and the modern bony fishes. Here also are relics of Eocene turtles and crocodiles and of a large marine snake. The specialist will note, with interest, the type-specimens of *Gastornis Klaasseni*, a gigantic wingless bird from the Woolwich beds of Croydon, described by Mr. E. T. Newton. The Eocene mammalia are of necessity but scantily represented.

Pliocene vertebrata, mostly from the so-called coprolite workings in the East Anglian Crags are well illustrated by the fine series in the Wall Cases of Recess No. 16. The large triangular teeth of the shark, *Carcharodon megalodon*; the ear-bones and teeth of whales; the hard bony beaks, or rostra, of other cetaceans (*Mesoplodon*); portions of walrus tusks (*Trichechus*); and teeth of mastodon, rhinoceros, tapir, hipparion, &c., are among the more notable of these Crag vertebrata.

A rich collection of the vertebrate fossils of the Norfolk Forest-bed, a late Pliocene formation, is lodged in Recess 17, and in the Table Case (F) of Recess 16. A large number of these specimens were bequeathed to the Museum by the Rev. S. W. King, of Cromer. Here will be found excellent examples of the teeth of several kinds of elephant; as also relics of a rhinoceros, the hippopotamus, a gigantic beaver and various carnivora; nor should we omit mention of the large series of bones of the smaller forms of animal life, such as the voles, often overlooked by collectors.

In order to study the *Pleistocene Vertebrata* the visitor must descend to the Lower Gallery, where he will find a rich collection from the river-drifts and bone-caves of Britain. These are displayed in Cases 1, 2, and 3, and in the extension of the range

of Wall Cases to the southern end of the Western Gallery, over the Ceramic Department of the Museum. Some also are placed in the Table Cases (A, B) of the embayments. The Pleistocene collection includes the rich series made by the late Dr. Cotton, from the brick-earths of Ilford in Essex. Conspicuous among the Pleistocene fossils are the enormous limb-bones, the tusks and the grinding-teeth of the mammoth, or great hairy elephant of the north; and special note should be made of the mammoth remains found in 1892, during drainage operations in Endsleigh Gardens, and described by Dr. Hicks. Other pleistocene mammals, well-represented here, are the woolly rhinoceros, the hippopotamus—of which a large series of relics is exhibited from Barrington in Cambridgeshire—the great urus, the bison, the musk-ox—of which a fine skull, with horn cores, is exhibited from Crayford in Kent—the cave-bear, the cave-hyæna, the cave-lion, the Irish big-horn, &c. The Table Case (A) in Recess 2 contains a collection of *mammalian teeth* illustrating the dentition of certain Pleistocene genera. It may be well to state that the stone-implements of palæolithic man, the contemporary of the extinct pleistocene mammals, will be found in Case No. 23 on the Ground Floor. (*See* p. 51.)

ROCK ROOM.

A room entered from the southern end of the Upper Gallery is devoted to the exhibition of a Collection of Rocks, and is consequently known as the *Rock Room*, or *Petrographical Gallery*. In front of the Entrance stands a model, by Sir Archibald Geikie, showing the geological structure of the *Isle of Eigg*, one of the Inner Hebrides. The doorway is surmounted by a fine pair of antlers of the great extinct *Irish Deer* (*Cervus megaceros*); and there is also placed over the door a gilt ball representing the *Sun*, and forming one of the series of models illustrating part of the Solar system, already referred to (p. 145).

Immediately in front of the visitor, on entering the Rock Gallery, is a Table Case (A) containing selected examples of *Rock-forming Minerals*. The student will find here a compact collection, restricted to such mineral-species as are important in petrographical study. It commences with the series illustrating the varieties of Quartz; the number of specimens having been, of set purpose, limited, and each specimen being distinctly labelled so as to tell its own meaning. A glass shelf, placed above, supports a number of wooden models illustrating the typical forms of crystals of quartz; whilst with these are associated certain sketches, by Mr. F. Rutley, showing the appearance which quartz presents when viewed in thin sections under the microscope. Then follow the felspars, forming a compact and important group; and these are succeeded by the

hornblendes, augites, &c. The same arrangement is followed throughout the series; the student finding in each case the mineral, the model, and the microscope section. The essential constituents of the common crystalline rocks are followed by a series of accessory minerals and secondary products—the whole forming a group not large enough to bewilder a beginner, yet sufficiently extensive to lay the foundation of sound petrographical knowledge.

From the case of rock-forming minerals the student should pass to the range of Wall Cases (B) erected at the western end of the Room, or right hand from the entrance, and containing specimens in illustration of the chief *Rock types*. Here we see a rather large selection of rock-specimens, brought together without regard to locality, for the purpose of showing the principal varieties of rocks. The series commences with the *igneous rocks*, or those which have existed in a more or less molten condition. Some of these have consolidated under pressure at great depths, and are hence called *plutonic*, whilst others which have solidified rapidly under superficial conditions are termed *volcanic*. So far as chemical composition is concerned, we recognise first an *acid* group, containing rocks rich in silica, such as granite, felsite, rhyolite, and obsidian. The acid group, in which the silica varies from 75 to 65 per cent. is followed by an *intermediate* group, containing from 65 to 55 per cent. of silica, and including such rocks as syenite, diorite, and andesite, whilst the *basic* group includes rocks poor in silica, like gabbro, dolerite, and basalt, in which the silica may be as low as 45 per cent. Finally, an *ultra-basic* group, with less than 45 per cent. of silica, has been formed for the reception of the peridotites, picrites, and serpentines.

Then follows the series of *sedimentary* rocks, arranged in three groups, according as their formation has been due to *mechanical*, *organic*, or *chemical* agencies. The *metamorphic* series, though rather ill-defined, is here made to comprehend the gneisses, the crystalline schists, and the clay slates. The preceding petrological classification, though by no means free from imperfection, is probably the best scheme for the general use of the student.

At the opposite, eastern or left-hand end of the Gallery, is a range of Cases (C) devoted to the exhibition of specimens illustrative of *Rock structures*. In the first compartment we find, among others, some beautiful examples of *porphyritic* structure, or that structure in which distinct crystals of certain minerals are embedded in a base of finer texture (*see also* p. 20). Then follows an interesting suite of specimens showing *globular* structures, such as are typically developed in the beautiful orbicular diorite from Corsica, known also as Napoleonite. In the next Case are varied examples of the structures displayed by volcanic rocks, including the *vesicular* and *amygdaloidal* types; in the former the lava presents a cavernous texture, due to the disengagement of gas or vapour, usually steam, while the

lava was in a plastic state: in the latter these cavities have been filled, to a greater or less extent, by various minerals deposited as secondary products (*see* Agates, p. 54).

In the next Case of this series are some excellent illustrations of the lamination, bedding, jointing, cleavage and faulting of rocks—so far at least as such divisional planes can be shown in small specimens. A *faulted slate*, showing a series of fractures and miniature dislocations, is especially noteworthy. Finally, there are here some beautiful examples of *columnar structure*, both in igneous and sedimentary rocks; and some curious *concretions* and illustrations of other physical structures, including the so-called "cone-in-cone."

The following Case contains an exceptionally interesting series in illustration of the *mechanical deformation* of rocks. Here we see fossils squeezed, stretched and distorted by pressure; pebbles in conglomerates compressed and elongated, and the mineral constituents of other rocks so drawn out that a banded or schistose structure is developed. The effects of prolonged earth-movement are strikingly shown by a beautiful series of specimens from the Alps, in which the rocks, even on a small scale, show folding and contortion, amounting in some cases to sharp puckering. Nor are equally fine examples wanting from the British Isles—as witnessed by many specimens shown in this Case from the old rocks of parts of Scotland and Ireland. In the north-west Highlands, for instance, vast masses of rock have been dragged bodily over one another for many miles, thus subjecting the rocks along the gliding surfaces, or thrust-planes, to severe shearing stresses, which have profoundly affected their physical structure, and even, in places, their mineral composition. Here also may be seen some interesting specimens presented by Dr. Hans Reusch, from near Bergen, in Norway, in which the impressions of Silurian fossils occur in micaceous phyllites or schists.

In the centre of the Petrographical Room, opposite to the Case of rock-forming minerals, is a Table Case (D) devoted to illustrations of the *action of various disintegrating agencies*, such as wind, water, and ice. It is not easy to illustrate such natural operations by museum specimens; and hence sketches and photographs are added to assist in explaining the phenomena on a large scale. The first compartment of the case contains specimens showing the action of *ice*. Here are examples of rock-surfaces which have been ground, polished and scratched by glaciers; samples of detritus, or moraine-matter, carried by moving land-ice and various ice-borne boulders. The larger boulders are necessarily placed in some of the lower compartments of the neighbouring Cases.

The effects of *wind* and *water*, as agents of denudation, are illustrated to a limited extent; it is shown, for instance, how rocks may be scored and pebbles polished by means of drifting sand. And here, too, are some curious examples of the action of

various *organisms* in boring into, and otherwise destroying, rocks.

On the opposite side of the Case the subject of denudation is further illustrated by many specimens showing the *weathering* of rocks—an alteration effected in large measure by the chemical action of rain and percolating waters. Thus, it will be seen that the felspars of certain granitic rocks are decomposed and converted into china-clay; whilst other specimens show how a "blue-hearted" rock may become more or less rusty on the surface by the production of hydrated oxide of iron, due to the effect of the oxygen dissolved in waters which percolate through the rocks.

Finally, an attempt is here made to illustrate certain phases of *metamorphic action*, showing especially the alteration which rocks may suffer, when invaded by an igneous intrusion. Shales, for instances may be more or less calcined; sandstones may be converted into quartzites; coal may be coked; or a compact limestone may assume a crystalline structure and pass into a statuary marble.

The remainder of the Petrographical Gallery is occupied by a collection of *British Rocks*, which, for extent and completeness is unrivalled. In the arrangement of these rocks a chronological sequence is observed: the series commencing in Wall Case No. **1** with the Archæan, or oldest known rocks, from the north-west of Scotland, and thence proceeding regularly, as far as possible in ascending stratigraphical order, through the successive geological formations. The Cases along the south wall of the Room, numbered **1** to **17** contain specimens illustrating the *Pre-Cambrian*, the *Cambrian*, and the *Silurian* rocks. In the upper part of each Wall Case, at too great a height for the convenient display of specimens, there is placed a geological map of the particular area from which the specimens in the Case below have been obtained; whilst in many of the Cases illustrations of the microscopic structure of the rocks are introduced, in the form of coloured plates from Mr. Teall's "British Petrography."

Above the range of Wall Cases on each side of the Gallery are bold diagrammatic sections, which serve at once to enliven the Room, and to illustrate the natural relations of the strata.

The stratigraphical series is continued in the Wall Cases on the opposite or northern side of the Room. To the west of the doorway leading into the Gallery is a range of cases (Nos. **18** to **21**) devoted to the *Devonian rocks* and *Old Red Sandstone.* The rocks of Cornwall and Devon, including the "killas," or clay-slate, of the former and the fossiliferous limestones of the latter county, are well represented; and here, as elsewhere in the collection, the associated igneous rocks are exhibited, so that we find in these Cases representatives of such rocks as the granites of Cornwall and Devon and of the volcanic series

of Brent Tor. The Old Red Sandstone of Scotland and its associated volcanic rocks also find their place in this series.

The long range of Cases on the eastern side of the doorway (Nos. **22** to **30**) is devoted to the *Carboniferous system.* The Carboniferous Limestone series naturally claims a large space; but a still ampler allowance is allotted to the Coal-measures. The arrangement is here topographical, each coal-field being fairly represented. Occasionally a specimen will be found displaying a typical fossil, but it should be borne in mind that it is not the object of this part of the Museum to illustrate the organic remains which occur in the stratified rocks, and the representatives of the coal-flora should consequently be sought in the palæontological collection. A fine series of specimens illustrating the calciferous sandstone series of Scotland and the volcanic rocks in the Carboniferous system of Northern Britain will be found in the cases now under description. No space is available in the Wall Cases for the illustration of formations above the carboniferous system, and the remainder of the stratigraphical collection has consequently to be accommodated in the four large Pedestal Cases, which are conspicuous objects in the Central Area of the Room. Illustrative geological sections, drawn and coloured by hand, are suspended in the upper part of each Pedestal Case, to assist the student in realising the mode of occurrence of the rocks which are represented by specimens in the lower part of the Case.

From the Carboniferous formation, which terminates in Wall-Case No. **30**, we pass to illustrations of the *Permian system* in the opposite Pedestal Case, numbered in Sections, 31 to 40. Here we note not only the red sandstones and marls but the dolomite, or magnesian limestone; and the eye is arrested by the concretionary forms assumed by some of the calcite in the dolomitic series of the north of England. The volcanic series of presumably Permian age found in Ayrshire and Devonshire is illustrated in this Case. The Triassic group is well represented—the lower or *Bunter* division by its variegated sandstones, and the upper or *Keuper* division by its sandstones and marls. Rock-salt and gypsum are exhibited as characteristic minerals of the New Red Marl. The *Rhœtic* beds—so named from their typical development in the Rhætic Alps—form a connecting link between the Trias and the Lias, and are here represented by several specimens, including the curious "Landscape Marble" of Bristol. The *Lias* makes a great show in this Case, some of the specimens being rich in ammonites, belemnites and other characteristic fossils. Here, too, we note the limestones of the Lower Lias, so valuable as cement-stones; the ironstones of the Marlstone, or Middle Lias, extensively worked in the Cleveland district; and the shales of the Upper Lias, forming the matrix of the Whitby jet, and formerly worked for the manufacture of alum.

It is customary to unite the Lias with the overlying Oolites under the general name of the *Jurassic system.* The Case numbered 41 to 50 is devoted to the important group of Oolitic strata, which have been mentioned in an earlier part of this guide as yielding some of our valued building stones (p. 30), as well as the fissile limestones known as the Stonesfield and Collyweston "slates" (p. 36). The various sub-divisions of the oolites, from the Inferior Oolite to the top of the Purbeck series are well represented by rock-specimens in this series.

The opposite Case, numbered in sections, 51 to 60, is set apart for illustrations of the rocks of the *Cretaceous System.* Commencing with the fresh-water beds of the Weald, which include the Hastings sand and the Weald clay, we pass thence to the marine beds of the Lower Greensand. Mention has already been made of the "Sussex marble" from the Weald clay (p. 31), as well as of the "Kentish Rag" from the Hythe beds of the Lower Greensand (p. 30). Passing upwards we meet successively the Gault clay, the Upper Greensand, and the Chalk. The eye will be attracted by the specimens of Red Chalk, a rock which occurs at the base of the White Chalk in the fine cliff-section at Hunstanton, in Norfolk, and is found also in Lincolnshire and Yorkshire. The varied forms of flint and the curious nodules of iron-pyrites claim attention; whilst the visitor should also notice the hard varieties of chalk known as "Melbourn Rock" and "Chalk Rock"—the former occurring at the base and the latter at the top of the Middle Chalk. Here, too, are examples of the phosphatic chalk of Taplow, discovered a few years ago by Mr. A. Strahan.

In the last Case, the compartments of which are numbered 61 to 70, will be found a collection of typical rocks of *Tertiary* and later date. The large section across the London Basin, displayed in the upper part of this Case, may be advantageously studied in connexion with the examples of *Eocene* rocks. Specimens from the Eocene, or Lower Tertiary, series are exhibited not only from the Metropolitan area but also from the Hampshire basin, including part of the Isle of Wight; and with these may be associated the Tertiary basaltic rocks of the north-east of Ireland and the west of Scotland. Photographs of exceptional size and beauty, illustrating the characteristic scenery formed by the columnar basalt of the Giants' Causeway, are suspended on the neighbouring wall. The *Oligocene* beds, more recent in age than the Eocene deposits, are represented by specimens from the fluvio-marine series of the Isle of Wight. It is now believed that strata of *Miocene* age are not present in Britain; but the succeeding *Pliocene* period is represented, partly by the "Crags," or shelly sands, of East Anglia, and partly by certain fragmentary deposits at St. Erth, in West Cornwall, and at Lenham, in Kent.

In illustration of the *Pleistocene* or *Quaternary* period there are here exhibited numerous specimens from the glacial drift, from

ancient river-deposits and from certain bone-caves. The Recent or Historical period is represented by a series of deposits now in course of formation on the sea-bottom around Britain, as also by samples of peat, modern conglomerates, stalagmites, &c.

It will be noted that the stratigraphical series is thus brought to an end exactly opposite to the starting-point in the first Wall Case containing the collection of archæan rocks. A detailed handbook to the Rock Room is in course of preparation, and consequently this department of the Museum has been only very briefly described in the preceding pages.

INDEX.

A.

B.

C

D.

E.

F.

T.

THE MUSEUM OF PRACTICAL GEOLOGY,

Jermyn Street, S.W.,

Is open to the Public FREE on every week-day, except Christmas Day and Good Friday, and except during the period when it is annually closed for repairs, namely, from the evening of August 9 until the morning of September 10.

On Mondays and Saturdays the Museum is open from 10 o'clock a.m. until 10 o'clock p.m. On other days the Museum is open from 10 a.m. until 4 o'clock p.m. during the months of November, December, January, and February, and until 5 o'clock during the rest of the year.

GENERAL MEMOIRS OF THE GEOLOGICAL SURVEY.

REPORT on CORNWALL, DEVON, and WEST SOMERSET. By Sir H. T. De La Beche. 14s. (O.P.)
FIGURES and DESCRIPTIONS of the PALÆOZOIC FOSSILS in the above Counties. By Prof. Phillips. (O.P.
The MEMOIRS of the GEOLOGICAL SURVEY of GREAT BRITAIN Vol. I., 21s.; Vol. II. (in 2 Parts), 42s.
N. WALES. By Sir A. C. Ramsay. App., by J. W. Salter and R. Etheridge. 2nd Ed. 21s. (Vol. III. of Memoirs, &c.)
LONDON BASIN. Pt. I. Chalk & Eocene of S. & W. Tracts. By W. Whitaker. 13s. (Vol. IV. of Memoirs, &c.) (O.P.)
Guide to the GEOLOGY of LONDON and the NEIGHBOURHOOD. By W. Whitaker. 5th Ed.
TERTIARY FLUVIO-MARINE FORMATION of the ISLE of WIGHT. By Edward Forbes. 5s.
The ISLE OF WIGHT. By H. W. Bristow. New Ed. By C. Reid and A. Strahan. 8s. 6d.
The WEALD (PARTS of the COUNTIES of KENT, SURREY, SUSSEX, and HANTS). By W. Topley. 17s.
The TRIASSIC and PERMIAN ROCKS of the MIDLAND COUNTIES of ENGLAND. By E. Hull. 5s.
The FENLAND. By S. B. J. Skertchly. 36s. 6d.
The MANUFACTURE of GUN FLINTS. By S. B. J. Skertchly. 16s.
The SUPERFICIAL DEPOSITS of SOUTH-WEST LANCASHIRE. By C. E. De Rance. 10s. 6d.
NORTH DERBYSHIRE. By A. H. Green, C. Le Neve Foster, and J. R. Dakyns. 2nd Ed. By A. H. Green and A. Strahan. 5s. 6d.
BURNLEY COAL FIELD. By E. Hull, R. H. Tiddeman [and Others]. 12s.
YORKSHIRE COALFIELD. By A. H. Green, R. Russell [and Others]. 42s.
EAST SOMERSET and BRISTOL COALFIELDS. By H. B. Woodward. 18s.
SOUTH STAFFORDSHIRE COAL-FIELD. By J. B. Jukes. (3rd Edit.) (*Out of print.*) 3s. 6d.
WARWICKSHIRE COAL-FIELD. By H. H. Howell. 1s. 6d.
LEICESTERSHIRE COAL-FIELD. By Edward Hull. 3s.
ERUPTIVE ROCKS of BRENT TOR. By F. Rutley. 15s. 6d.
FELSITIC LAVAS of ENGLAND and WALES. By F. Rutley. 9d.
HOLDERNESS. By C. Reid. 4s.
The PLIOCENE DEPOSITS of BRITAIN. By C. Reid. 5s. 6d.
The JURASSIC ROCKS OF BRITAIN.—Vol. I. YORKSHIRE, 8s. 6d., Vol. II. YORKSHIRE, Fossils, 12s. By C. Fox-Strangways. Vol. III. LIAS OF ENGLAND (Yorkshire excepted). 7s. 6d. By H. B. Woodward. Vol. IV. The Lower Oolitic Rocks of England. 10s. By H. B. Woodward. Vol. V. The Middle and Upper Oolitic Rocks of England. 7s. 6d. By H. B. Woodward.
BRITISH ORGANIC REMAINS. Decades I. to XIII., with 10 Plates each Price 4s. 6d. each 4to; 2s. 6d. each 8vo.
MONOGRAPH I. On the Genus PTERYGOTUS. By T. H. Huxley, and J. W. Salter. 7s.
MONOGRAPH II. On the Structure of the BELEMNITIDÆ. By T. H. Huxley. 2s. 6d.
MONOGRAPH III. On the CROCODILIAN REMAINS found in the ELGIN SANDSTONES. By T. H. Huxley.
MONOGRAPH IV. On the CHIMÆROID FISHES of the British Cretaceous Rocks. By E. T. Newton. 5s.
The VERTEBRATA of the FOREST BED SERIES of NORFOLK and SUFFOLK By E. T. Newton. 7s. 6d.
The VERTEBRATA of the PLIOCENE DEPOSITS of BRITAIN. By E. T. Newton. 4s.
Museum Catalogues, &c.: —
ROCK SPECIMENS. By A. C. Ramsay, H. W. Bristow, H. Bauerman, and A. Geikie. 1s. (3rd Edit.) (O. P.)
HANDBOOK to the COLLECTION of BRITISH POTTERY and PORCELAIN. 1s.
FOSSILS:—CAMBRIAN and SILURIAN, 2s. 6d.; CRETACEOUS, 2s. 9d.; TERTIARY and POST-TERTIARY, 1s. 8d.

SHEET MEMOIRS OF THE GEOLOGICAL SURVEY.

Those marked (O.P.) are Out of Print.

1, 2, 7 - - GEOLOGY OF LONDON, &c. By W. Whitaker. Vol. I., 6s. Vol. II., 5s.
4 - - FOLKESTONE and RYE. By F. Drew. 1s.
12 - - S. BERKSHIRE and N. HAMPSHIRE. By H. W. Bristow and W. Whitaker. s. (O.P.)
13 - - PARTS of OXFORDSHIRE and BERKSHIRE. By E. Hull and W. Whitaker. 3s. (O.P.)
34 - - PARTS of WILTS, and GLOUCESTERSHIRE. By A. C. Ramsay, W. T. Aveline, and E. Hull. 8d.
44 - - CHELTENHAM. By E. Hull. 2s. 6d.
45 - - BANBURY, WOODSTOCK, and BUCKINGHAM. By A. H. Green 2s.
45 SW - - WOODSTOCK. By E. Hull. 1s.
47 - - N.W. ESSEX & N.E. HERTS. By W. Whitaker, W. H. Penning, W. H. Dalton, & F. J. Bennett. 3s. 6d.
48 SW - - COLCHESTER. By W. H. Dalton. 1s. 6d.
48 SE - - EASTERN END of ESSEX (WALTON NAZE and HARWICH). By W. Whitaker. 9d.
48 NW, NE. IPSWICH, HADLEIGH, and FELIXSTOW. By W. Whitaker, W. H. Dalton, and F. J. Bennett, 2s.
49 S, 50 SE - ALDBOROUGH, &c. By W. H. Dalton. Edited, with additions, by W. Whitaker. 1s.
49 N - - SOUTHWOLD. By W. Whitaker. 2s. 6d.
50 SW - - STOWMARKET. By W. Whitaker, F. J. Bennett, and J. H. Blake. 1s.
50 NW - - DISS, EYE, &c. By F. J. Bennett. 2s.
50 NE - - HALESWORTH and HARLESTON. By W. Whitaker and W. H. Dalton. 1s.
51 SW - - CAMBRIDGE. By W. H. Penning and A. J. Jukes-Browne. 4s. 6d.
51 SE - - BURY ST. EDMUNDS and NEWMARKET. By F. J. Bennett, J. H. Blake, and W. Whitaker. 1s.
51 NE - - PARTS of CAMBRIDGESHIRE and SUFFOLK. By W. Whitaker [and Others]. 2s.
53 SE - - PART of NORTHAMPTONSHIRE. By W. T. Aveline and Richard Trench. 8d.
53 NE - - PARTS of NORTHAMPTONSHIRE and WARWICKSHIRE. By W. T. Aveline. 8d. (O.P.)
63 SE - - PART of LEICESTERSHIRE. By W. Talbot Aveline and H. H. Howell. 8d. (O.P.)
64 - - RUTLAND, &c. By J. W. Judd. 12s. 6d.
65 - - S.W. NORFOLK and E. CAMBRIDGESHIRE. By W. Whitaker, S. B. J. Skertchly and A. J. Jukes-Browne. 3s.
66 NE, SE - NORWICH. By H. B. Woodward. 7s.
66 SW - - ATTLEBOROUGH. By F. J. Bennett. 1s. 6d.
66 NW - - E. DEREHAM. By J. H. Blake. 1s. 6d.
67 - - YARMOUTH and LOWESTOFT. By J. H. Blake. 2s.
68 E - - CROMER. By C. Reid. 6s.
68 NW, SW. FAKENHAM, WELLS, &c. By H. B. Woodward. 2s.
70 - - S.W. LINCOLNSHIRE, &c. By A. J. Jukes-Browne and W. H. Dalton. 4s.
71 NE - - NOTTINGHAM. By W. T. Aveline. (2nd Ed.) 1s.
79 NW - RHYL, ABERGELE, and COLWYN. By A. Strahan. (Notes by R. H. Tiddeman.) 1s. 6d.
79 SE - - FLINT, MOLD, and RUTHIN. By A. Strahan (Parts by C. E. De Rance). 4s. 6d.
80 NW - PRESCOT, LANCASHIRE. By E. Hull. (3rd Ed. With additions by A. Strahan.) 3s.
80 NE - - ALTRINCHAM, CHESHIRE. By E. Hull. 8d. (O.P.)
80 SW - - CHESTER. By A. Strahan. 2s.
81 NW, SW. STOCKPORT, MACCLESFIELD, CONGLETON, & LEEK. By E. Hull and A. H. Green. 4s.
82 SE - - PARTS of NOTTINGHAMSHIRE and DERBYSHIRE. By W. T. Aveline. (2nd Ed.) 6d.
82 NE - - PARTS of NOTTINGHAMSHIRE, YORKSHIRE, and DERBYSHIRE. By W. T. Aveline. 8d.
83 - - LINCOLN. By W. A. E. Ussher, A. J. Jukes-Browne, and A. Strahan. 3s.
84 - - EAST LINCOLNSHIRE. By A. J. Jukes-Browne. 3s. 6d.
86 - - N. LINCOLNSHIRE and S. YORKSHIRE. By W. A. E. Ussher [and Others]. 2s.
87 NW - - PARTS of NOTTS, YORKSHIRE, and DERBYSHIRE. (2nd Ed.) By W. T. Aveline. 6d.
87 SW - - BARNSLEY. By A. H. Green. 9d.
88 SW - - OLDHAM. By E. Hull. 2s.

88 SE - - PART of the YORKSHIRE COAL-FIELD. By A. H. GREEN, J. R. DAKYNS and J. C. WARD. 1s.
88 NE - - DEWSBURY, &c. By A. H. GREEN, J. R. DAKYNS, J. C. WARD and R. RUSSELL. 6*d.*
89 SE - - BOLTON, LANCASHIRE. By E. HULL. 2*s.*
89 SW - - WIGAN. By EDWARD HULL (2nd Ed.) 1*s.* (O.P.)
90 SE - - The COUNTRY between LIVERPOOL and SOUTHPORT. By C. E. DE RANCE. 3*l.* (O.P.)
90 NE - - SOUTHPORT, LYTHAM, and SOUTH SHORE. By C. E. DE RANCE. 6*d.*
91 SW - - The COUNTRY between BLACKPOOL and FLEETWOOD. By C. E. DE RANCE. 6*d.*
91 NW - - SOUTHERN PART of the FURNESS DISTRICT in N. LANCASHIRE. By W. T AVELINE. 6*d.*
92 SE - - BRADFORD and SKIPTON. By J. R. DAKYNS, C. FOX-STRANGWAYS, R. RUSSELL, and W. H. DALTON. 6*d.*
93 NW - - NORTH and EAST of HARROGATE. By C. FOX-STRANGWAYS. 6*d.*
93 NE - - The COUNTRY between YORK and MALTON. By C. FOX-STRANGWAYS. 1*s.* 6*d.*
93 NW - - N. and E. of LEEDS, and near TADCASTER. By W. T. AVELINE, A. H. GREEN (and others). (O.P.)
93 SE 94 W COUNTRY between YORK & HULL. By J. R. DAKYNS, C. FOX-STRANGWAYS, and A. G. CAMERON. 1*s.*
94 NW - - DRIFFIELD. By J. R. DAKYNS and C. FOX-STRANGWAYS. 9*d.*
94 NE - - BRIDLINGTON BAY. By J. R. DAKYNS and C. FOX-STRANGWAYS. 1*s.*
95 SW, SE - SCARBOROUGH and FLAMBOROUGH HEAD. By C. FOX-STRANGWAYS. 1*s.*
95 NW - WHITBY and SCARBOROUGH. By C. FOX-STRANGWAYS and G. BARROW. 1*s.* 6*d.*
96 SE - NEW MALTON, PICKERING, and HELMSLEY. By C. FOX-STRANGWAYS. 1*s.*
96 NE - - ESKDALE, ROSEDALE, &c. By C. FOX-STRANGWAYS, C. REID and G. BARROW. 1*s.* 6*d.*
96 NW, SW NORTHALLERTON and THIRSK. By C. FOX-STRANGWAYS, A. G. CAMERON, and G. BARROW. 1*s.* 6*d.*
97 SW - - INGLEBOROUGH. By J. R. DAKYNS, R. H. TIDDEMAN, W. GUNN, and A. STRAHAN. 2*s.*
97 NW - - MALLERSTANG, with parts of WENSLEYDALE, SWALEDALE, and ARKENDALE.
98 SE - - KIRKBY LONSDALE and KENDAL. By W. T. AVELINE, T. MC K. HUGHES, and R. H. TIDDEMAN. 2*s.*
98 NE - - KENDAL. By W. T. AVELINE and T. MC K. HUGHES. 2nd Ed. by A. STRAHAN. 2*s.*
101 SE - NORTHERN PART of the ENGLISH LAKE DISTRICT. By J. C. WARD. 9*s.*
104 SW, SE NORTH CLEVELAND. By G. BARROW. 1*s.* 6*d.*
108 SE OTTERBURN and ELSDON. By HUGH MILLER. 2*s.* 6*d.*
108 NE - CHEVIOT HILLS. By C. T. CLOUGH. 1*s.* 6*d.*
108 SW - PLASHETTS and KIELDER. By C. T. CLOUGH. 1*s.*
110 SW - WOOLER and COLDSTREAM. By W. GUNN and C. T. CLOUGH.

THE MINERAL DISTRICTS OF ENGLAND AND WALES.

COAL-FIELDS.—Scale, one inch to a mile.

Anglesey, 78 (SW).
Bristol and Somerset, 19, 35.
Coalbrook Dale, 61 (NE & SE).
Clee Hill, 53 (NE, NW).
Flintshire and Denbighshire, 74 (NE & SE), 79 (NE, SE).
Derby and Yorkshire, 71 (NW, NE, & SE), 82 (NW & SW), 81 (NE), 87 (NE, SE), 88 (SE).
Forest of Dean, 43 (SE & SW).
Forest of Wyre, 61 (SE), 55 (NE).
Lancashire, 80 (NW), 81 (NW), 89, 88 (SW, NW).
Leicestershire, 71 (SW), 63 (NW).
Northumberland & Durham, 103, 105, 106 (SE), 109 (SW, SE).
N. Staffordshire, 72 (NW), 72 (SW), 73 (NE), 80 (SE), 81 (SW)
S. Staffordshire, 54 (NW), 62 (SW).
Shrewsbury, 60 (NE), 61 (NW & SW).
South Wales, 36, 37, 38, 40, 41, 42 (SE, SW).
Warwickshire, 62 (NE, SE), 63 (NW, SW), 54 (NE), 53 (NW).
Whitehaven, 101 (NW, NE, SW.).
Yorkshire, 88 (NE, SE), 87 (SW), 92 (SE), 93 (SW).

COAL-FIELDS AND OTHER MINERAL DISTRICTS—
Scale, six inches to a mile.

The Coal-fields and other mineral districts of the N. of England are published on a scale of six inches to a mile, at 4*s.* to 6*s.* each. MS. Coloured Copies of other six-inch maps, not intended for publication, are deposited for reference in the Geological Survey Office, 28, Jermyn Street, London.

Lancashire.

Sheet 15, Ireleth.—16, Ulverstone.—17, Cartmel.—22, Aldingham —47, Clitheroe.—48, Colne.—49. Laneshaw Br.—55, Whalley.—56, Haggate.—57, Winewall.—61, Preston.—62, Balderstone.—63, Accrington.—64, Burnley.—65, Stiperden Moor.—39, Layland.—70, Blackburn.—71, Haslingden.—72, Cliviger, Bacup.—73, Todmorden.—77, Chorley.—78, Bolton - le - Moors.—79, Entwistle.—80, Tottington.—81, Wardle.—84, Ormskirk.—85, Standish.—86, Adlington.—87, Bolton-le-Moors.—88, Bury, Heywood.—89, Rochdale, &c. —92, Bickerstaffe.—93, Wigan.—94, West Houghton.—95, Radcliffe.—96, Middleton, Prestwich.—97, Oldham.—100, Knowsley.—101, Billinge.—102, Leigh, Lowton.—103, Ashley, Eccles.—104, Manchester, Salford.—105, Ashton-under-Lyne.—106, Liverpool.—107, Prescott.—108, St. Helen's.—109, Winwick.—111, Cheedale.—112, Stockport.—113, Part of Liverpool.

Durham.

Sheet 1, Ryton.—2, Gateshead.—3, Jarrow.—4, S. Shields. —5, Greenside.—6, Winlaton.—7, Washington.—8, Sunderland.—9, Pt. of Hunstanworth.—10, Edmondbyers —11, Ebchester.—12, Tantoby.—13, Chester-le-St.—15, Killhope Moor.—16, Hunstanworth.—17, Waskerley.—18, Muggleswick.—19, Lanchester.—20, Hetton-le-Hole.—22, Wear Head. —23, Eastgate.—24, Stanhope.—25, Wolsingham.—26, Brancepeth.—30, Benny Seat.—32, White Kirkley.—33, Hamsterley.—34, Whitworth.—38, Maize Beck.—41, Cockfield — 42, Bp. Auckland.—46, Hawksley Hill Ho.—52, Barnard Castle.—53, Winston.

Northumberland.

Sheet 44, Rothbury.—45, Longframlington.—46, Broomhill.—47, Coquet Island.—54, Longhorsley.—55, Ulgham.—56, Druridge Bay.—63, Netherwitton.—64, Morpeth.—65, Newbiggin.—72, Bedlington.—73, Blyth.—80, Cramlington.—81, Earsdon.—82, NE. of Gilsland.—83, Coadley Gate.—37, Heddon.—88, Long Benton.—89, Tynemouth.—91, Greenhead.—92, Haltwhistle.—93, Haydon Bridge.—94, Hexham.—95, Corbridge. —96, Horsley.—97, Newcastle.—98, Walker.—101, Whitfield.—102, Allendale Town.—103, Slaley.—105, Newlands.—106, Blackpool Br.—107, Allendale.—108, Blanchland. —109, Shotleyfield.—110, Wellhope.—111, 112, Allenheads.

Cumberland.

Sheet 24 (and 26A) Kirkby Ravensworth.—55, Searness.—56, Skiddaw.—63, Thackthwaite.—64, Keswick.—65, Dockraye. — 69, Buttermere.—70, Grange.—71, Helvellyn.— 74, Wastwater.—75, Stonethwaite Fell.

Westmorland.

Sheet 2, Tees Head.—6, Dufton Fell.—12, Patterdale.—18, Near Grasmere.—25, Grasmere.—38, Kendal.

Yorkshire.

Sheet 3, Lune Forest.—7, Redcar.—8, 9, Saltburn, &c.—11, Cotherstone Moor.—12, Bowes.—13, Wycliffe.—17, Guisboro'. —20, Lythe.—24, Kirkby Ravensworth.—25, Aldborough.—32, 33, Whitby.—38, Marske.—39, Richmond.—46, Little Beck.—47, Robin Hood's Bay.—53, Downholme.—68, Leybourne.—82, Kidstones.—84, E. Witton.—97, Foxup.—98, Kirk Gill.—99, Haden Carr.—100, Lofthouse.—115, Arncliffe.—116, Conistone Moor.—133, Kirkby Malham.—152, Blubberhouses. —184, Dale End.—185, Kildwick.—200, Keighley.—201, Bingley.—202, Calverley.—203, Seacroft.—204, Aberford.—215, Peeke Well.—216, Bradford.—217, Calverley.—218, Leeds.—219, Kippax.—231, Halifax.—232, Birstal.—233, East Ardsley.—234, Castleford.—246, Huddersfield.—247, Dewsbury.—248, Wakefield.—249, Pontefract.—250, Darrington.—260, Honley.—261, Kirkburton.—262, Darton.—263, Hemsworth.—264, Campsall.—272, Holmfirth.—273, Penistone.—274, Barnsley.—275, Darfield.—276, Brodsworth.—281, Langsell.—282, Wortley.—283, Wath upon Dearne.—284, Conisborough.—287, Low Bradford.—288, Ecclesfield.—289, Rotherham.—290, Braithwell.—293, Hallam Moors.—295, Handsworth.—296, Laughton-en-le-Morthen.—299, Waleswood.—300, Harthill.

MINERAL STATISTICS.

The produce of Coals, Metallic Ores, and other Minerals. By R. HUNT. From 1853 to 1857, inclusive, 1*s.* 6*d.* each. 1858, *Part I.*, 1*s.* 6*d.*; *Part II.*, 5*s.* 1859, 1*s.* 6*d.* 1860, 3*s.* 6*d.* 1861, 2*s.*; and Appendix, 1*s.* 1862, 2*s.* 6*d.* 1863, 2*s.* 6*d.* 1864, 2*s.* 1865, 2*s.* 6*d.* 1866 to 1881, 2*s.* each. (These Statistics are now published by the *Home Office.*)

THE IRON ORES OF GREAT BRITAIN.

Part I. The North and North Midland Counties of England (*Out of print*). Part II. South Staffordshire. Price 1*s.* Part III. South Wales. Price 1*s.* 3*d.* Part IV. The Shropshire Coal-field and North Staffordshire. 1*s.* 3*d.*

BLEICHERT'S AERIAL TRANSPORTERS LIMITED / LONDON

EGYPT HOUSE / 36 NEW BROAD STREET
LONDON E. C. / TEL.: LONDON WALL 3277
TEL.-ADR.: BLEICHERT AVE LONDON